Catholic University of Sudan

GONZAGA UNIVERSITY

SCHOOL OF ENGINEERING

FINAL REPORT

FOR

CATHOLIC UNIVERSITY OF SUDAN, AFRICA

Center for Engineering Design

Project CENG 491 01

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INTRODUCTION

The Catholic University of Sudan (CU of S) in Juba Sudan is a continuation of a Senior Design project from 2008-09. The University project has been designed through the coordination of the Catholic Church in Juba, MSAADA Architects, and with the assistance of this design team. The finished product is a nearly comprehensive set of construction documents that include drawings, specifications, and calculations.

BACKGROUND

The country of Sudan (Figure 1) has had a troubled past and is currently working to rebuild its economy and infrastructure. Through the second half of 2008, Sudan's economy has boomed due to an increase in oil production, high oil prices, and large inflows of foreign direct investment. Agriculture remains an important aspect of the economy since it employs nearly 80% of the work force and contributes a third of the Gross Domestic Product (World Fact Book). Impacts due to the Darfur conflict, a civil war which spanned from 1983 to 2005, a lack of basic infrastructure in large areas, and reliance by much of the population on subsistence farming, causes much of the population to remain at or below the poverty line despite rapid rises in average per capita income. Sudan still remains one of the poorer countries in the world with a per capita income of $2,200 per year in 2008 (World Fact Book). While the country's literacy rate as a whole has improved dramatically, with a rise from 43% in 2000 to 61.1% in 2008, efforts have been complicated by the equally large increase in total population to 41,000,000 (estimated July 2009-World Fact Book). In an effort to bring the nation out of poverty and promote just and responsible leaders, the Catholic Church, along with potential help of the United States Agency for International Development (USAID), has started the process of building a new Catholic University of Sudan in Juba.

Prior efforts on the project are summarized to provide the background information on the project.

Figure 1: Map of Sudan

PROJECT HISTORY

Although the history of the CU of S actually began over half a century ago with the Church's original aspiration to found an institution of higher learning in Sudan, it can more recently be traced to 2003. In that year, Cardinal Gabriel Zubeir Wako began a feasibility study which led to a decision in 2007 by the Catholic Bishops of Sudan to establish the CU of S. The Bishops' paramount goal is to develop responsible leaders for Sudan. These leaders will help to revive a nation that was economically and socially devastated by more than two decades of civil war. Specifically, the bishops intend to train agriculturalists, environmentalists, engineers, educators, public health practitioners, lawyers and social scientists.

The Catholic Bishops of Sudan asked Fr. Mike Schultheis to coordinate the planning and establishment of the University. Fr. Schultheis, a Jesuit priest of the Oregon Province, worked for four years as the first President of the Catholic University of Ghana. He is now in Sudan and acts as the primary source of site-specific information for this project.

Fr. Schultheis approached Gonzaga University to sponsor the CU of S as an engineering Senior Design Project in 2008. Gonzaga has received support from a local civil engineer, Kennet Bertelsen, who also coordinates with MSAADA Architects. MSAADA is a non-profit architectural and engineering firm based in Minneapolis that specializes in church-sponsored projects, particularly in developing countries. MSAADA is the primary party responsible for the overall site layout and architectural design. With the help of Kennet Bertelsen, John Dacquisto, and MSAADA, conceptual engineering drawings and a cost estimate were produced for use in a USAID/American Schools & Hospitals Abroad (ASHA) funding application.

PROJECT GOALS

As of May 2010, the funding from the USAID/ASHA grant has yet to be determined. A new application for additional funding will submitted in June 2010 by Fr. Schultheis which will include the most current design. At present, the final project site has of yet to be selected, though it has been narrowed down to two possible sites within the outskirts of Juba. MSAADA final cost estimates from our design considerations will be determined by MSAADA prior to June 2010, and no longer fall within the scope of the project.

Fr. Schultheis conveyed to MSAADA some of his general design goals in May of 2008. He envisions a university campus constructed in multiple phases, as funding and enrollment increase for an eventual capacity of 1000 students. The buildings are planned to be arranged in a cluster-style, and have the outward appearance of typical South Sudan structures. The main administration building will include several classrooms, faculty offices, and computer labs.

Last year, the student team did preliminary structural design. The civil aspects of the site development were considered by the students and recommendations were made concerning the water supply system, sanitary sewer/septic facilities, electrical power supply (including possible solar power generation) and grading of the site. Their structural analyses, utilizing a representative cross section of the building and "typical" members, were adequate for a preliminary cost estimation of the structures, but with the design package for this submission a more accurate cost estimate can be determined.

This project has several design concerns associated with this project with initial construction cost being one of the most important issues. Since the project is within a developing country, specific project considerations, such as labor and material costs, are different from projects in the Spokane area; labor costs are much lower while material costs are significantly higher. The necessity of this project is also emphasized, since the CU of S already has more than thirty students enrolled and permanent facilities are needed for further educational development.

SCOPE

In order to provide the necessary construction documents and specifications for this project, several deliverables have been developed including; structural drawings, water and wastewater design options, and site development plans. Along with specific goals and requisites supplied by MSAADA, this year's project is drawing upon information gathered by the previous year's project team. Though the goals of the project have generally remained unchanged, this year's scope is including a more exact and detailed study of the elements pertaining to each facet of the project. These have been done with the expectation of providing a more prescribed and complete rendering of those deliverables crucial to the success and aim of the venture.

The main design requirements composing the project include the following;

STRUCTURAL DESIGN

In accordance with building requirements and specifications provided by MSAADA Architects the team has developed roof, floor, and foundation plans as well as details. The plans contain design of structural elements including roof trusses, beams, columns, walls, footings, slabs, and general details regarding connections of building members. The material specifications are in accordance with both national standards and international codes including those set forth in the ASCE 7-05 Standard, ACI 318-08, AISC Code, 2006 International Building Code (IBC), MSJC Masonry Code, and the ACI 530-05. These designs are based on the fore mentioned codes, though due to the location of the project as well as cost restrictions, project designs may not meet all U.S. design requirements.

ROOF DESIGN

The roof was designed based on a Howe truss configuration. Due to both economic constraints as well as availability of materials in the area, the truss members were designed to be steel double angles with an assumed strength of 248 MPa (36 ksi). Four different load cases were analyzed on each of the three truss configurations to determine the maximum force that would be acting on the truss members (See Appendix A1.1). Using the AISC Steel Construction Manual: Allowable Loads for Axial Compression, the size of double angles needed were established. For the one story building, a 2L 76 x 76 x 6.4 (2L 3 x 3 x 1/4) will be used. For both configurations of the two story buildings a 2L 76 x 76 x 6.4 (2L 3 x 3 x 1/4) will also be used for the main trusses. Since the hip girder trusses support more of the roof, the truss members were designed to be made out of slightly larger double angles. For the main two-story building (south) a 2L 76 x 76 x 7.9 (2L 3 x 3 x 5/16) will be used. The hip truss on the main two-story building (north) will be constructed out of a 2L 89 x 89 x 7.9 (2L 3 ½ x 3 ½ x 5/16). Welded connections were designed based on a weld thickness of 5mm (3/16 in), and assuming a minimum weld length of 5cm (2in) (Appendix A1.1). Depending on the contractor selected, wood trusses may be used instead.

FIRST FLOOR DESIGN

For the design of the First Floor reinforced concrete t-beams, the American Concrete Institute (ACI) 318-08 Code Edition was used. The loads were determined per the design criteria found in Appendix I and are based upon the ASCE-7. For example, a live load of 610 kgf/m^2 (125 psf) was used for the north wings and a live load of 195 kgf/m^2 (40 psf) was used for the classrooms in the south wing. The beams share similar dimensions to maintain a uniform appearance to and to reduce construction costs. Beams B3-B10 have dimensions of 23 cm x 45 cm (9 in x 18 in). The use of ACI Coefficients were used for beam calculations and the maximum loading was used to design for entire section. In this manner a conservative design would be determined to protect against any variance in material quality or other construction issues which may arise due to the project's location. In many cases minimum flexural reinforcing and maximum spacing for shear reinforcement was found to govern. The only major variation in the first floor t-beams occurs in the south-center wing in which the beam depth was increased to 23 cm x 66 cm (9 in. x 26 in.) due to the longer span of 915 cm (30 ft) in order to limit deflections. A summary of the beam schedule can be seen in Figure 3. The beam locations can be seen in Appendix A2.2 and an example design for flexure, shear, and deflection can be seen in Appendix A2.1.

The slabs were designed in the same manner as the beams. The northeast and northwest wings have a slab depth of 15 cm (6 in) and the south wing has a slab depth of 13 cm (5 in). The transverse reinforcement was taken to be the minimum required to counter shrinkage and temperature changes. The calculations for these results can be found in Appendix A2.3 and a summary of the results can be seen in Figure 3.

Figure 3: Beam Schedule

Beam	Dim	As	Stirrups	Slab Height (cm)	As $_{flexure}$	As $_{temp}$
B1	23x66	4Y29	Y 10 @ 25	13	Y13 @ 25	Y10 @ 20
B2	23x66	2Y25	Y 10 @ 25	13	Y13 @ 25	Y10 @ 20
B3	23x45	2Y19	Y 10 @ 17	13	Y13 @ 25	Y10 @ 20
B4	23x45	2Y19	Y 10 @ 17	15	Y13 @ 25	Y10 @ 17
B5	23x45	2Y22	Y 10 @ 17	15	Y13 @ 25	Y10 @ 17
B6	23x45	2Y25	Y 10 @ 15	15	Y13 @ 25	Y10 @ 17

COLUMN DESIGN

All of the reinforced concrete columns in the buildings are 23 cm x 23 cm (9in x 9in) with (4) #19 vertical bars. Analyses for slender columns were done using a computer program . Loads on columns were taken to be a live load of 98 kgf/m^2 (20 psf) and a dead load of 73 kgf/m^2 (15 psf) from the roof and a first floor live load of 610 kgf/m^2 (125 psf) and a maximum dead load of 488 kgf/m^2 (100 psf) for the first floor. Height of columns were reduced from 330 cm (10.83ft) to 263 cm (8.63ft) to take into account the depth of the beams coming into the columns.

FOOTING DESIGN

Strip footings were designed around the perimeter of the building and below structure walls. Spread footings were incorporated to support the columns. The allowable soil bearing pressure used was 14,647 kgf/m^2 (3,000 psf). The final results can be seen in Appendix 1.1.

LATERAL DESIGN

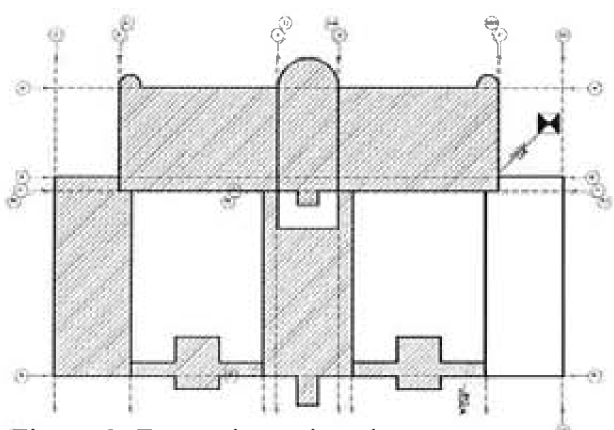


Figure 2: Expansion Joint Plan

Wind and seismic loads were calculated for the buildings to determine the controlling lateral load. We designed for a 3 second gust wind speed of 100 m.p.h. and an exposure C. The seismic force was assumed as 12% of the building weight based on comparison with similar locations. We determined that seismic forces controlled the lateral design. CMU shear walls were designed to be comprised of 23 x 40 cm (9 in x 16 in) fully grouted-reinforced concrete masonry units. The location and size of each shear wall was determined by expansion joint locations and building layout specified by MSAADA (Fig 2). In order to design the shear walls for the two-story buildings both a rigid and flexible diaphragm analysis was necessary. For the east and west one-story wings a flexible analysis was used for design (Appendix A3.1).

Allowable shear values for both unreinforced and reinforced walls were designed using ASCE-07, IBC, and MSJC Masonry Code. Mild reinforcing for walls were based on steel with a strength of 275.8 MPa (40ksi). The same bar size was used for all of the shear wall reinforcing for ease of construction. Two #13 bars (horizontal) at 81.3 cm o.c. (32 in) was the final acceptable design for all shear wall reinforcement (Appendix A3.3)

Reinforcement needed to account for overturning was designed using shear values obtained from the seismic analysis. The overturning moments caused by the seismic loads on the shear walls were calculated and the area of steel required to resist overturning was determined. The area of steel required for the shear walls can be found in Appendix A3.4.

CIVIL DESIGN

SITE DESIGN

The site plan has been designed based on a five acre site area. This is the minimal site area being considered, so our design will be suitable if the ten acre site were selected. The final site design includes location and details for the well and water tower, the septic system, the rain water collection tank, and general site grading specifications. The site plan can be found in Appendix B1 and 1.1.

WATER

To provide water for the campus, we designed a water supply system that would be adequate for the full capacity of the building. This included the evaluation of reusable and sustainable sources for water, pump design, and storage.

In order to design the well and pump system, the building water needs had to be evaluated. The necessary flow rate for the building was determined based upon the Design Standards from the US Department of Health for large onsite systems, under the criteria of a school with no showers or cafeteria. This flow rate was 37.8 liters per day per occupant. The total design occupancy of the university is 1,049 persons, which leads to a flow rate of 39,652 liters per day. Water use habits in East Africa, however, are substantially less consumptive than in the United States. Using this knowledge we reduced the original flow rate by 70% to get an accurate usage of 11,895 liters per day for the university. In order to confirm that reduction, data from the World Health Organization (WHO) was analyzed. According to the WHO information about water usage in East Africa, domestic water usage is about 16,000 liters per day. Taking into account that our building will not include showers, kitchens, etc., our estimation of 11,900 liters is confirmed.

A well will be drilled on site to supply the potable water to the building. Using the flow rate we determined an estimated amount of head needed to deliver the water from the well to the building. The pump was sized to meet this requirement based on Grundfoss pumps, and our selection was confirmed by a local Grundfoss dealer. Grundfoss pumps are internationally used and available for this project. Our final pump selection was a 1.5 horsepower, 60 hertz, and 240 volt pump. See Appendix B2.1 for the pump specifications and efficiency curve.

Once the water is out of the ground, storage will be necessary to ensure water supply when the pump may be unavailable due to lack of power or maintenance. A water tower (Appendix B3) capable of holding a day's supply of water is to be used and will be located near the pump in the back of the main building. The well pump will deliver the water from the well to the top of the water tower. From the water tower the water will be pumped into five cisterns (Appendix B2.4) strategically located throughout the building so that they are above the restrooms. The water movement from the tower to the cisterns and from the cisterns throughout the building will be gravity based. The height of the tower is set so that there will be enough hydraulic head to fill the cisterns based on their top elevation. The hydraulic profile for this configuration can be found in Appendix B10. The location and connections for these trusses are detailed in Appendix B4 and B5. The cisterns will be on girders spanning between trusses, as specified in Appendix B4.

WASTEWATER

The design of the water treatment systems for the building is an integral part of the civil plans for the site. We were asked to determine the best method for treatment of the wastewater and design a system that would meet the needs of the university.

In designing the wastewater treatment, we assumed that the amount of water needing treatment would be equal to the amount of water supplied to the buildings. Using an infiltration rate for the soil of 8 liters per day per square meter (conservative, supplied by MSAADA architects), a total area of 1,494 square meters was needed to provide adequate treatment of the wastewater. We evaluated several options for a treatment system. A treatment wetland was considered, but the complications surrounding the proper set up of an efficient wetland deterred us from selecting this as our design. We also considered utilizing MSAADA specifications for soakage pits in series because they created the smallest footprint on the site. The soakage pits are commonly constructed and used on similar projects and locations, and the small footprint was important because of the possible small five acre site size.

After preliminary design with soakage pits we decided to use a traditional septic tank and drain field combination. The reason of for this is its functionality - the excess water infiltrating the ground will make that land useful also as a garden system for the students. This makes the best use of our space and fulfills three important purposes – wastewater treatment, agricultural training, and garden space. Based on the daily volume of storage needed, three type seven septic tanks are to be used and a drain field of 1500 square meters will be constructed. The calculations for the septic and drain field design can be found in Appendix B6. See Appendix B7 for the septic tank design and the Site Plan in Appendix B1 for site location and details.

STORM WATER

The storm water calculations done for the site were based on limited rainfall data for Juba, Sudan. In order to have a complete analysis with this limited data, a site with similar precipitation characteristics as Juba was selected in Eastern Washington and calculations were based on its average rainfall and intensities. Leavenworth, WA was found to most closely match the rainfall patterns of Juba, and the Eastern Washington Storm Water Manual was used to calculate runoff using the Rational Method. Two sites were considered, one of five acres and one of ten acres. The runoff for typical storms during the rainy season was found not to be of concern enough to design for storm water collection and treatment. Instead, the site will be graded to accommodate runoff away from the building. The calculations, along with precipitation maps and data, hydrographs, and general site grading can be found in Appendix B8.

Along with the desires of MSAADA, a rainwater collection tank will be placed below ground to store precipitation runoff from the main building roof. The tank will be concrete in material and will have a capacity of 1000 liters. A hand pump will be used to extract the water which can be used for general landscaping and maintenance watering purposes. The location of this storage tank is near the back of the building, and details can be found on the site plan in Appendix B1.

ELECTRICAL DESIGN

We were asked to calculate the power requirements of the university in order to size a backup generator to supply electricity to the vital systems and elevator so that they would not be affected by fluctuations from the power grid in Juba going offline periodically throughout the week. Alternative sources of energy such as photovoltaic systems and site orientation for passive cooling were researched as well.

To determine the power requirements of the university, we looked to the U.S. for an analogous system. We reviewed the electrical specifications from the U.S. electrical code, which specifies an outlet every six feet along a wall, and then compared that to what is actually used in an average office/school setting. The result was that given a standard sized office with four outlets, typically only two are used on a daily basis. Using this practical approach of sizing power requirements only for what is actually used, we were able to get a total system draw of 125KW. If we had designed the power requirements as per the U.S. Electrical code, the total system draw would have summed to 154KW a higher wattage than was deemed necessary. Once the total demand had been calculated, we sized the power requirements for the vital systems, and came to the conclusion that a 125KW generator would supply enough power to prevent fluctuations to the computer labs, server room, and elevator. We have chosen to use a 125KW

Caterpillar diesel generator, as specified in Appendix B2.2, to provide the required backup power during the frequent times when the electrical grid is down.

In researching photovoltaic (PV) systems it was determined that a system large enough to cover a substantial portion of the electrical needs of the university would become cost prohibitive. Therefore we scaled back the design, and sized a PV system that would be large enough to power the well pump. The final PV system design that is specified in Appendix B2.3, utilizes a battery bank with a grid tie in so that in the event the solar panels need maintenance the well pump will still have power.

CIVIL SITE DESIGN COST ESTIMATES

The civil site design materials cost estimation has been determined (Appendix B9). The total estimated cost of materials was calculated to be $52,632. This will be used in the application for funding to be submitted in June 2010. Estimates will need to be adjusted based cost trends and the changing needs and requirements of the project in construction phase.

CONCLUSION

The drawings and design of the university building are to be used to provide a more detailed and comprehensive plan and will require review by MSAADA architects prior to final approval. Design of electrical and mechanical components are not included in the scope of this project except as related to a civil system designed within the scope of the project (i.e. solar system, backup power generators, etc).

Working on this project has provided us as students with the valuable opportunity to gain experience as engineers. We have learned how to apply the knowledge from our classes into a real world project similar to ones we will most definitely see in our careers. Being able to see this project from its earliest stages to its completion gave us a holistic sense of how a project is completed from start to finish. We have also felt a unique sense of purpose playing a role in a project that will fulfill a very noble function for the country of Sudan. We are thankful for Fr. Schultheis, MSAADA, Gonzaga University, Kennet Bertelson, DeAnn Arnholts, and Noel Bormann for the opportunity to participate in this project, for their guidance, support, and patience throughout the year. We can only hope that our work will endure throughout the life of this University as it edifies the country of Sudan to a peaceful and prosperous future.

Appendix 1

Appendix A: Structural Design

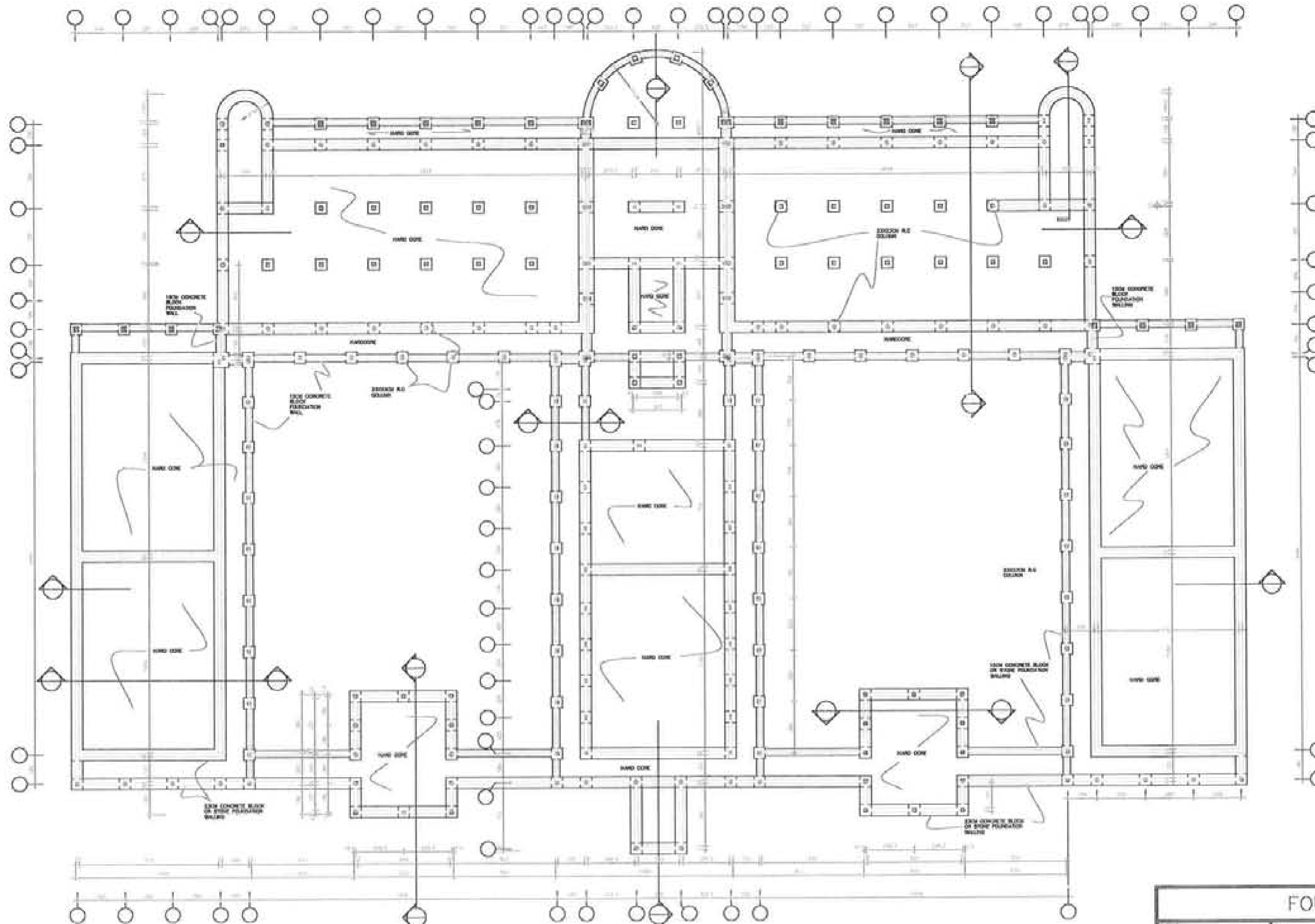
Appendix B: Civil Design

Appendix 1

Design Drawings

Ground Floor and Foundation Plans

1.1



FOUNDATION PLAN

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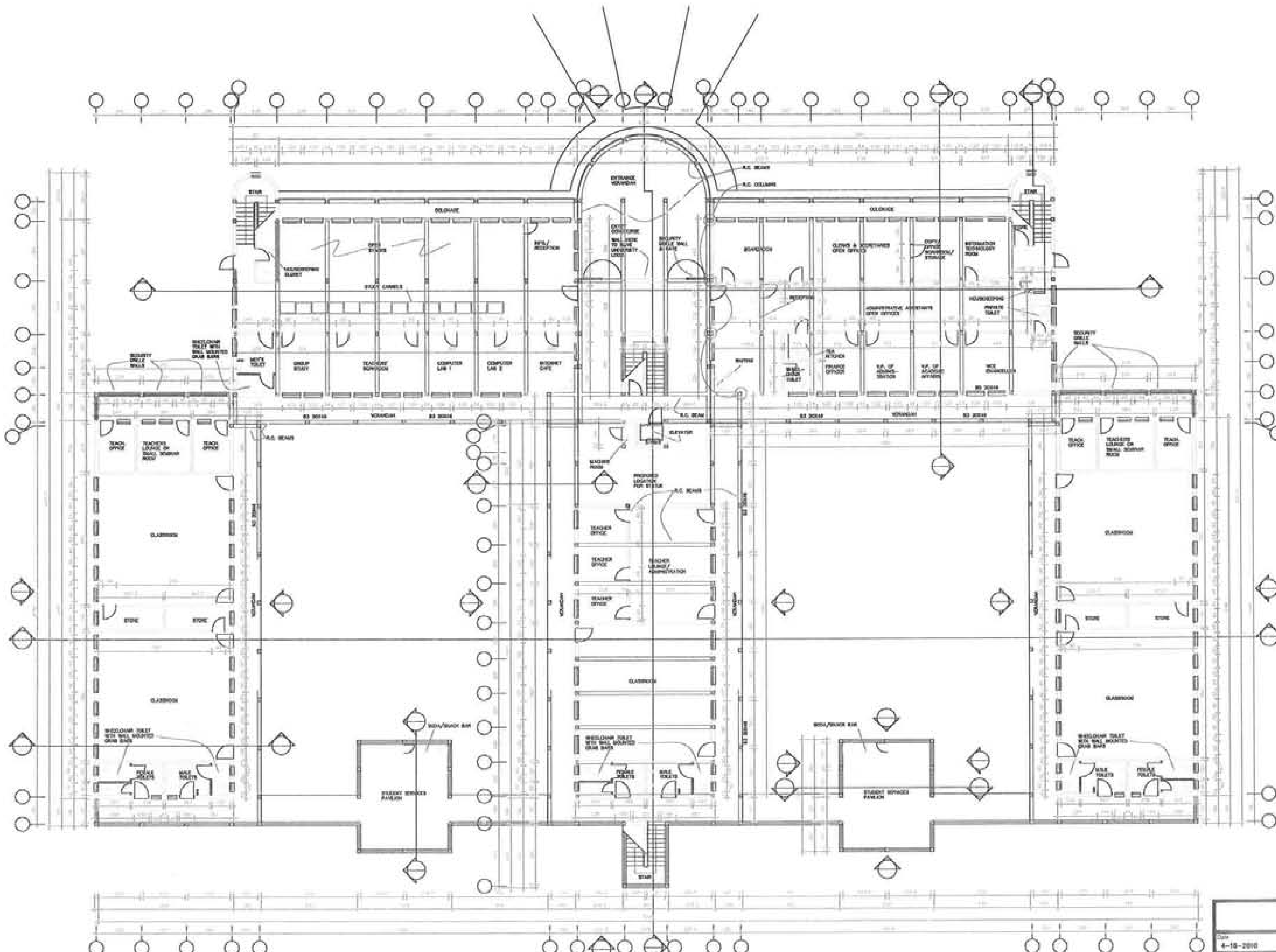

GROUND FLOOR PLAN

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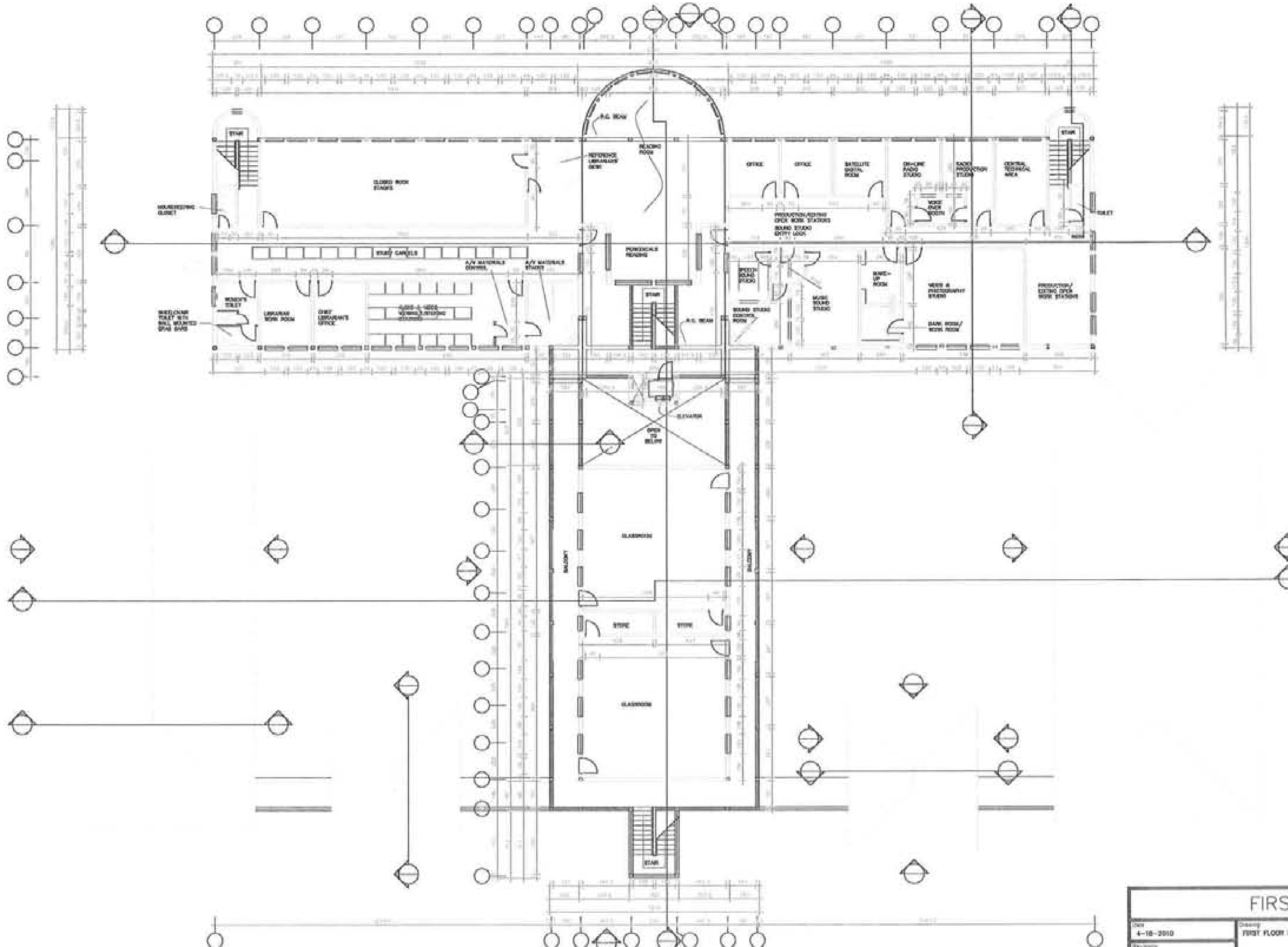
First Floor Plan

1.2



FIRST FLOOR PLAN

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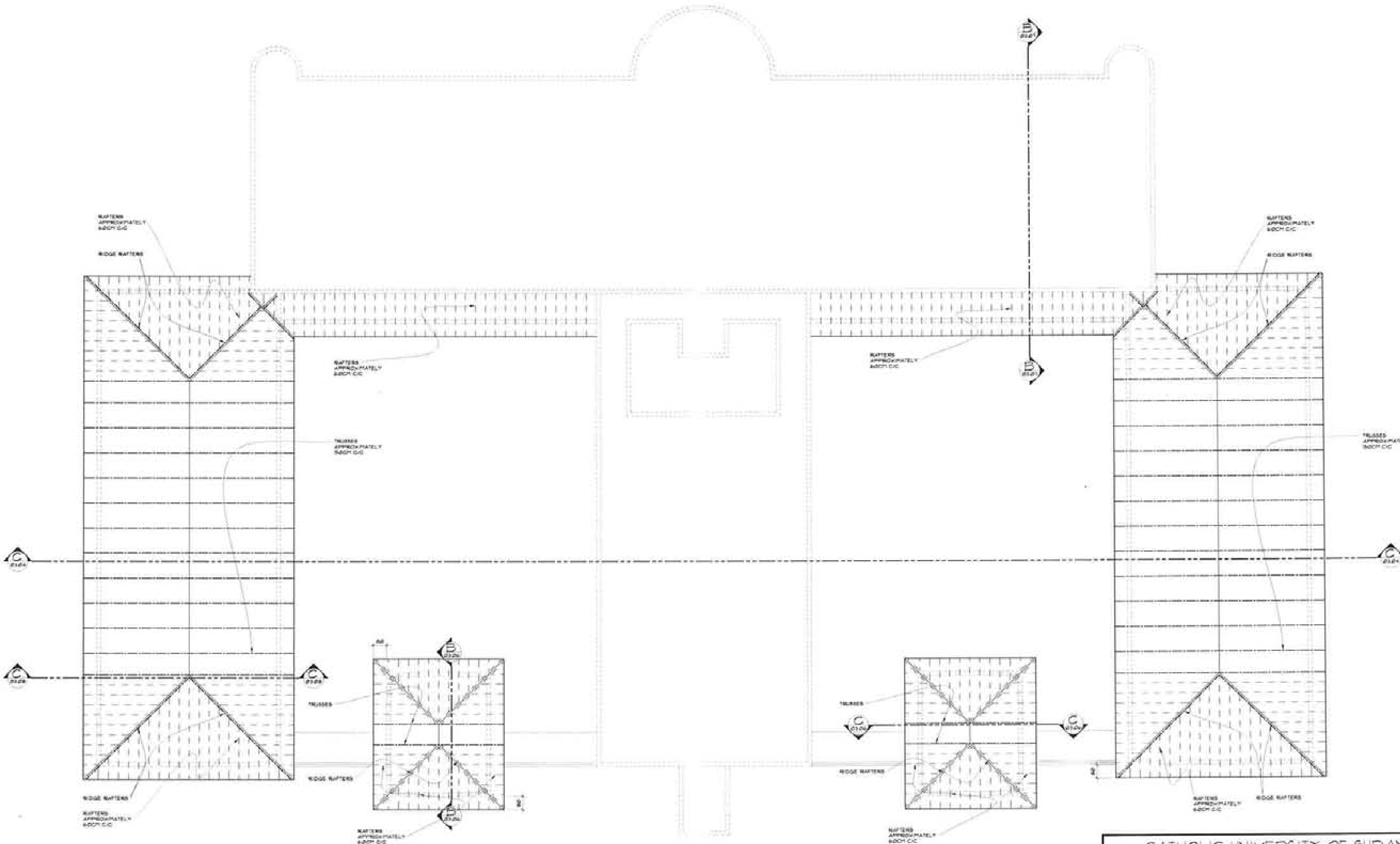
Approved		

Roof Framing Plans

1.3



ROOF FRAMING PLAN - GROUND FLOOR

NOT TO SCALE

CATHOLIC UNIVERSITY OF SUDAN

FACULTIES OF ARTS & SOCIAL SCIENCES for the CATHOLIC UNIVERSITY OF SUDAN IN JUBA, SUDAN

ROOF FRAMING PLAN - GROUND FLOOR

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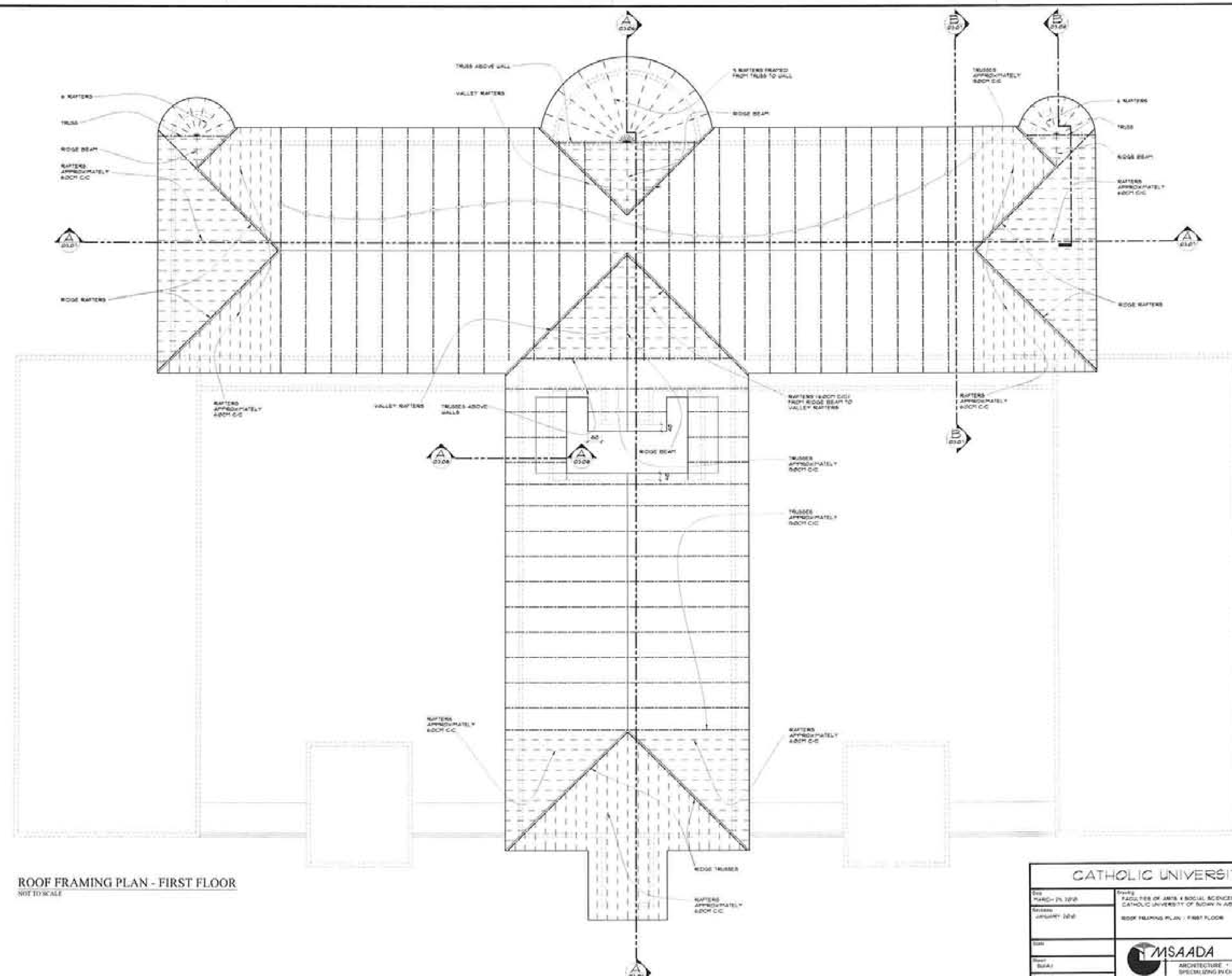

ROOF FRAMING PLAN - FIRST FLOOR

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CATHOLIC UNIVERSITY OF SUDAN

Date	Drawing: FACULTIES OF ARTS & SOCIAL SCIENCES for the CATHOLIC UNIVERSITY OF SUDAN IN JUBA, SUDAN ROOF FRAMING PLAN : FIRST FLOOR	SU 15.03.14
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Appendix A: Structural Design

Design Criteria

I

DESIGN CRITERIA

PROJECT:	Catholic University of Sudan		
LOCATION:	Juba, Southern Sudan		
Allowable Soil Bearing	3000 psf		
Frost depth			
Soil Site Class	D		
Roof Dead Load			
	Metal Roofing (24 ga)	1.3	psf
	3/4" plywood	2.3	
	Steel or wood trusses	5.0	
	Wood purlins (4x6) 40 pcf	1.8	
	Insulation	0.5	
	Ceiling (5/8" gypsum wall board)	2.8	
	Misc.	1.0	
	TOTAL DEAD LOAD	14.7	psf
	Use	**15.0**	**psf**
1st Flr DL at NE, NW and Center North			
	6" concrete slab	75.0	psf
	Concrete floor beams	15.0	
	Exterior conc beams	4.0	
	Ceiling	2.8	
	Misc.	2.0	
	TOTAL DEAD LOAD	98.8	psf
	Use	**100.0**	**psf**
1st Flr DL at Center South			
	5" concrete slab	63.0	psf
	Concrete floor beams	19.8	
	Exterior conc beams	4.0	
	Ceiling	2.8	
	Misc.	2.0	
	TOTAL DEAD LOAD	91.6	psf
	Use	**95.0**	psf
Live Loads			
	Roof	20	psf
	Library stack rooms	125	psf
	Classrooms	40	psf
	Corridors above 1st floor	80	psf
Wall weights			
CMU	8" solid grouted Normal wt	84	psf
Glass		10	psf

Truss Analysis

A1

TRUSS DESIGN ASSUMPTIONS

1. Dead Load $_{roof}$: 98 kgf/m^2 (20psf)
2. Live Load $_{roof}$: 73 kgf/m^2 (15psf)
3. Cistern Load: 907 kg (2000lb)
4. Wind Uplift: 49 kgf/m^2 (10psf)
5. Hip truss point load:

   One story: 10,750 kg (23,700lb)

   Two story: 14,580 kg (32,144lb)
6. Wind uplift: negligible (counteracted by dead load)
7. Loads are based on Allowable Strength Design (ASD)
8. Units: Calculations shown in English units. Final design dimensions are reported in metric units
9. For load cases 1-12 a 2L 3 x 3 x ¼ is assumed for determining element stresses/forces
10. Cistern: Assumed to be placed directly on truss member as a point load at the location of maximum influence.
11. Effective Lengths:

    One story: 305cm (10ft)

    Two story: 244cm (8ft)
12. Member Design: Based on AISC Steel Construction Manual Table 4-8.
13. Interior supports on north building assumed to take zero load from trusses
14. All truss members are to be steel
15. Weld length minimum = 51 mm (2 in.)

Truss Load Cases

A1.1

Truss Load Cases:

One Story Buildings (3 supports):

Case 1: Dead Load + Live Load

Case 2: Dead Load + Live Load + Cistern Point Load

Case 3: Dead Load + Live Load + Hip Truss Point Load

Case 4: Dead Load + Live Load + Hip Truss Point Load + Cistern Point Load

Two Story Buildings

Main Building-South (4 supports):

Case 5: Dead Load + Live Load

Case 6: Dead Load + Live Load + Cistern Point Load

Case 7: Dead Load + Live Load + Hip Truss Point Load

Case 8: Dead Load + Live Load + Hip Truss Point Load + Cistern Point Load

Main Building-North (2 supports):

Case 9: Dead Load + Live Load

Case 10: Dead Load + Live Load + Cistern Point Load

Case 11: Dead Load + Live Load + Hip Truss Point Load

Case 12: Dead Load + Live Load + Hip Truss Point Load + Cistern Point Load

Final Design:

One Story Buildings: 2L 3"x3"x1/4"

Two Story Buildings: Main Building-South: 2L 3"x3"x 1/4"

Hip Truss: 2L 3"x3"x 5/16"

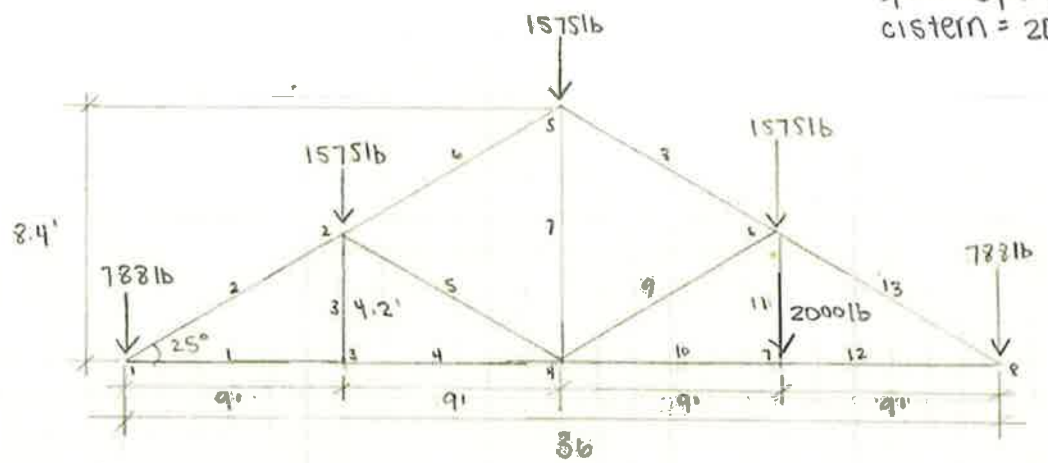
Main Building-North: 2L 3"x3"x 1/4"

Hip Truss: 2L 3 ½"x3 ½"x 5/16"

Load case 2 | TRUSS DESIGN -

One Story Buildings:

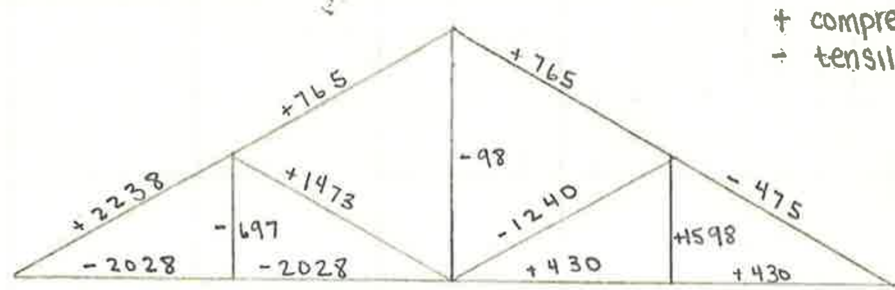
→ 5' trib. width
LL = 20 psf = 100 lb/ft
DL = 15 psf = 75 lb/ft
uplift: 10 psf (negligable)
cistern = 2000 lb



Analyzed by GS-USA with 2L3x3x 1/4:

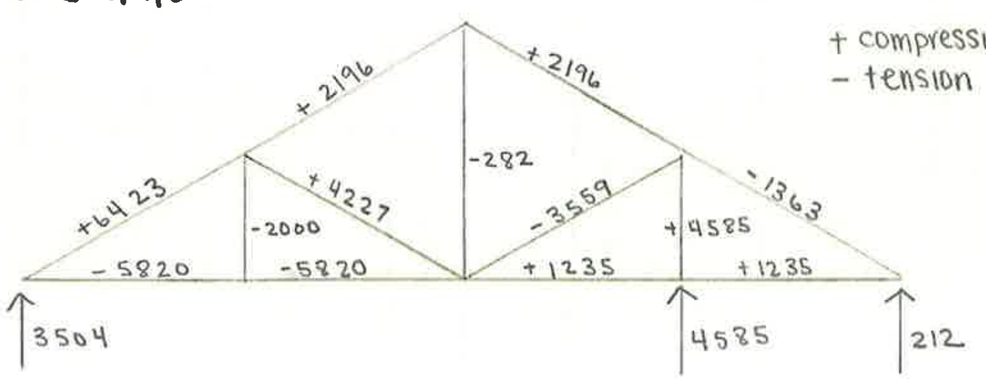
Element stresses: (psi)

+ compressive stress
- tensile stress



Element forces: (lb)
→ supports @ 1,7,8

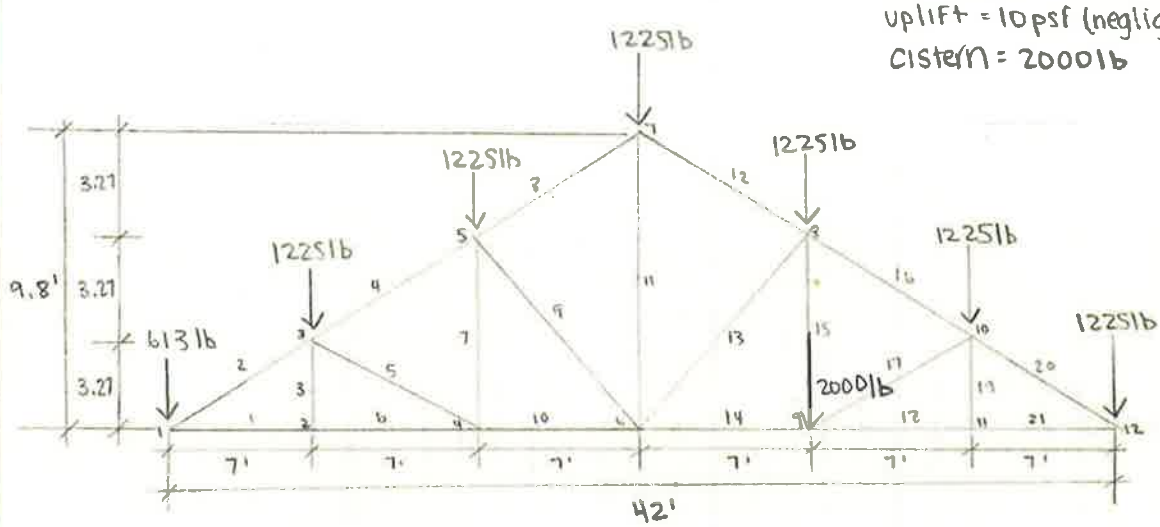
+ compression
- tension



Load case 6 | TRUSS DESIGN -

Two Story Buildings:

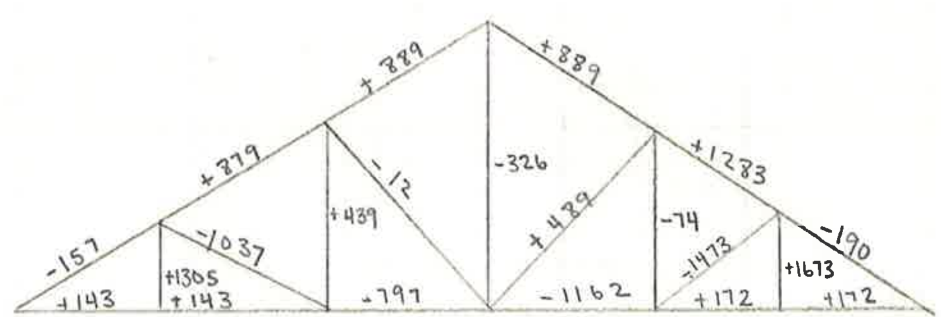
→ 5' trib width
LL = 20psf = 100lb/ft
DL = 15psf = 75 lb/ft
uplift = 10psf (negligable)
cistern = 2000lb



Analyzed by GS-USA with 2L3x3x1/4 :

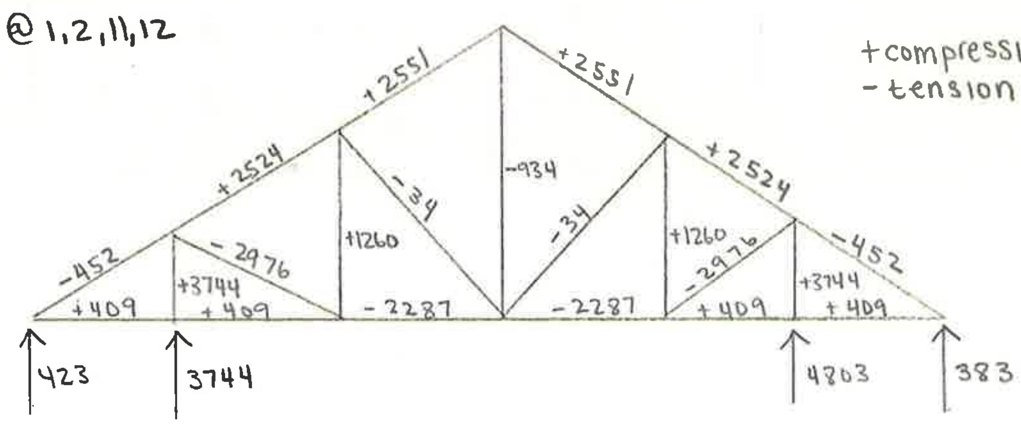
Element stresses: (psi)

+ compressive stress
− tensile stress



Element Forces: (lb)
supports @ 1,2,11,12

+ compression
− tension

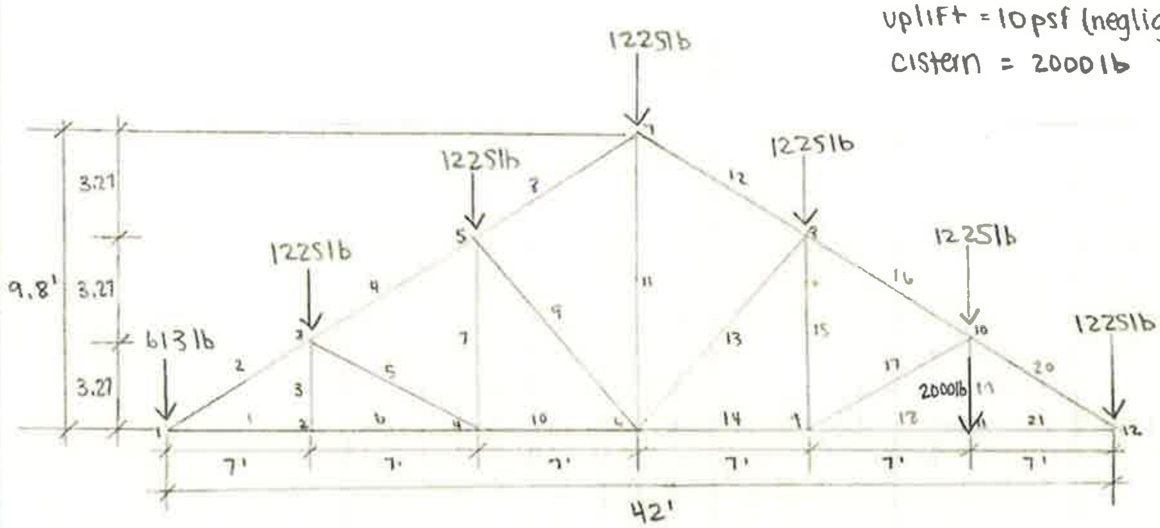


Load Case 10 | TRUSS DESIGN -

3-0235 — 50 SHEETS — 5 SQUARES
3-0236 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FILLER
COMET

Two Story Buildings:

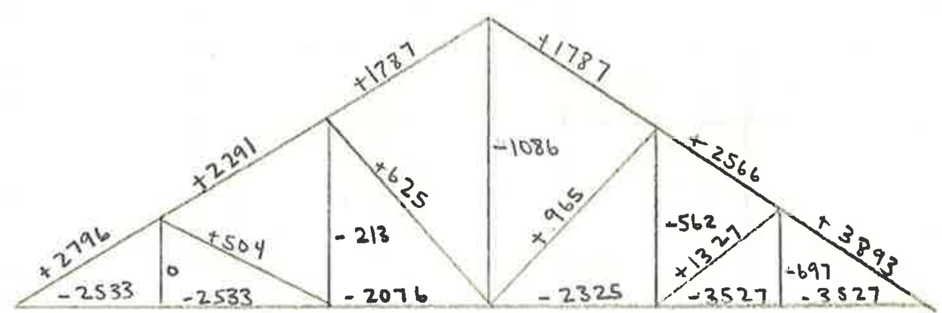
→ 5' trib width
LL = 20psf = 100 lb/ft
DL = 15psf = 75 lb/ft
uplift = 10psf (negligable)
cistern = 2000 lb



Analyzed by GS-USA with 2 L3x3x 1/4 :

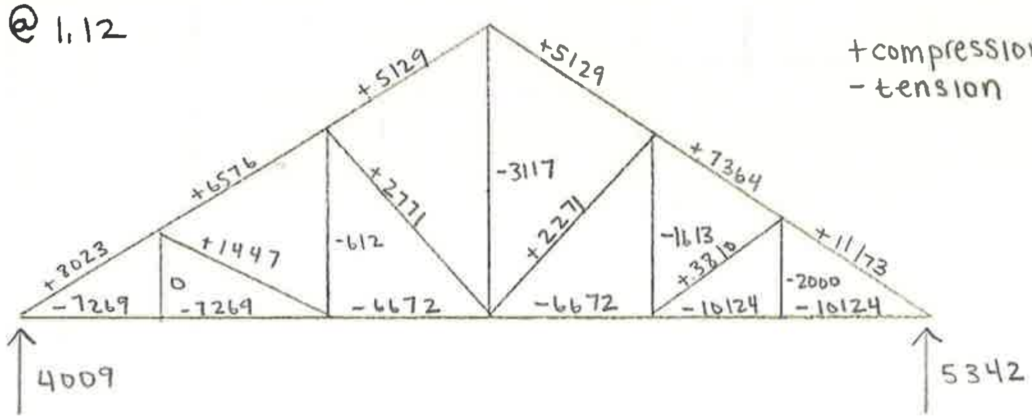
Element stresses: (psi)

\+ compressive stress
− tensile stress



Element Forces: (lb)
supports @ 1, 12

\+ compression
− tension



First Floor Design

A2

T-Beam Analysis

A2.1

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ASSIGNMENT | NAME

Beam Design

Assumptions:

$f_y = 40{,}000$ psi
$f'_c = 3{,}000$ psi

Calculations were performed in English units due to available codes and design experience. Results conservatively converted to metric.

Calculation Example: B1

Tributary width = 8 ft
Span = 30 ft
Live Load = 40 psf
Dead Load = 95 psf
(See design criteria sheet for calculation)

$W_{u_{LL}} = (40 \text{ psf})(8 \text{ ft}) = 320 \text{ plf}$

$W_{u_{DL}} = (95 \text{ psf})(8 \text{ ft}) = 760 \text{ plf}$

M_{max} pin-pin simple span $= \frac{W_u l^2}{8}$

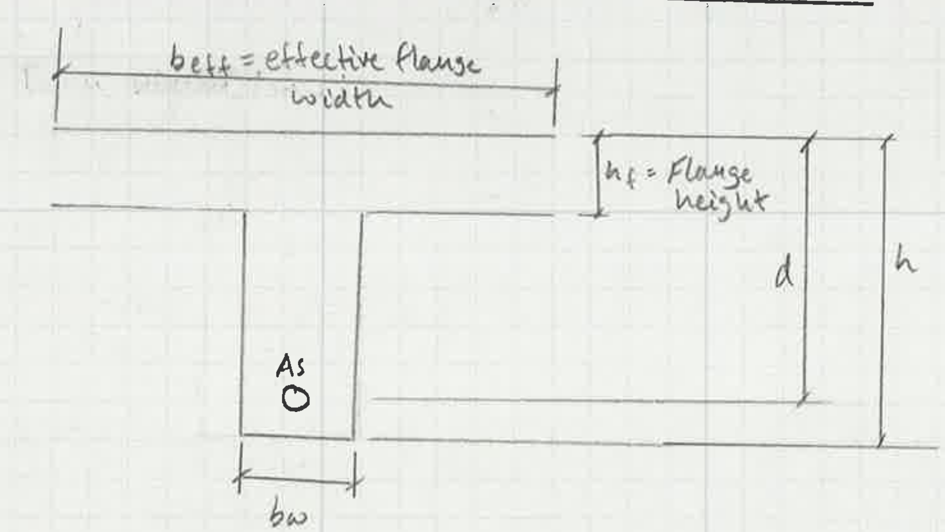
Note: For continuous beams in East and West Wings, American Concrete Institute coefficients are used to design for maximum positive and negative moments.

$M_{LL} = \frac{(320 \text{ plf})(30 \text{ ft})^2}{8} = 36{,}000$ lb-ft $= 36$ k-ft.

$M_{DL} = \frac{(760 \text{ plf})(30 \text{ ft})^2}{8} = 85{,}500$ lb-ft $= 85.5$ k-ft

$M_u = 1.2\, M_{DL} + 1.6\, M_{LL}$

$= 1.2\,(85.5 \text{ k-ft}) + 1.6\,(36 \text{ k-ft}) = \underline{160.2 \text{ k-ft}}$



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b_{eff} least of:
- $16 \times h_f + b_w$
- average clear distance to adjacent webs $+ b_w$
- span/4

Note: For edge beams where flange only extends from one side of web b_{eff} becomes least of:
- $6 h_f + b_w$
- Avg. clear distance to adjacent webs $+ b_w$
- b_w + span/4

For B1 with; $b_w = 9$ in
$d = 14$ in

- $16 \times 5\text{ in} + 9\text{ in} = 89\text{ in}$ ← governs
- $8\text{ ft} \times 12\text{ in/ft} + 9\text{ in} = 105\text{ in}.$
- $(30\text{ ft} \times 12\text{ in/ft})/4 = 90\text{ in}$

$R_n = \frac{M_u}{\phi b d^2}$ assuming $\phi = 0.9$ and therefore steel yields for ductile failure to occur.

$= \frac{(160.2\text{ k-ft} \times 12\text{ in/ft} \times 1000\text{ lb/k})}{(0.9)(9\text{ in})(14\text{ in})} = 49.59\text{ psi}$

$\rho = \frac{0.85 f'_c}{f_y}\left[1 - \sqrt{1 - \frac{2R_n}{0.85 f'_c}}\right]$

$= \frac{0.85(3000\text{ psi})}{40{,}000\text{ psi}}\left[1 - \sqrt{1 - \frac{2(49.59\text{ psi})}{0.85(3000\text{ psi})}}\right] = 0.00125$

$a = \frac{\rho f_y d}{0.85 f'_c} = \frac{0.00125(40{,}000\text{ psi})(14\text{ in})}{0.85(3{,}000\text{ psi})} = 0.43205\text{ in} < 5\text{ in}$ therefore "a" is within flange and beam acts as a rectangular beam.

$x = a/\beta_1 = \frac{0.43205\text{ in}}{0.85} = 0.508294\text{ in}$

$\varepsilon_t = \frac{d - x}{x} 0.003 = \left(\frac{14 - 0.508\text{ in}}{0.508\text{ in}}\right)0.003 = 0.12684411 > 0.005$ ∴ Beam is ductile ∴ $\phi = 0.9$ assumption is valid.

$A_s = \rho b d = 0.00125(9\text{ in})(14\text{ in}) = 2.45\text{ in}^2$

Check against A_s minimums:

$A_{s\,min} = \frac{3\sqrt{f'_c}}{f_y} b_w d = \frac{3\sqrt{3000\text{ psi}}}{40{,}000\text{ psi}}(9\text{ in})(14\text{ in}) = 0.81\text{ in}^2 < 2.45\text{ in}^2$

$A_{s\,min} = \frac{200}{f_y} b_w d = \frac{200}{40{,}000\text{ psi}}(9\text{ in})(14\text{ in}) = 0.99\text{ in}^2 < 2.45\text{ in}^2$

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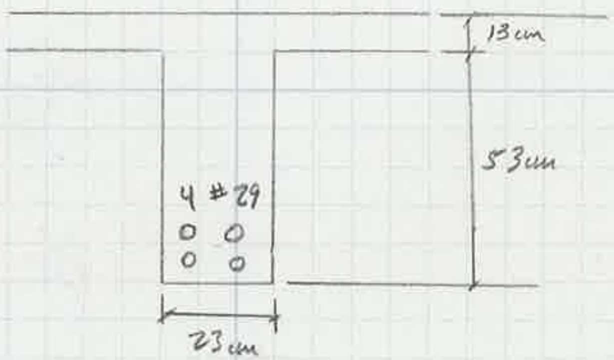
A_s req'd = 2.45 in^2
choose 4 #9's $A = 4$ in^2 chosen due to deflection limitations calculated

-In many cases minimal reinforcing is required such as with B3, B4, B5, B9, etc.

Results (Metric)



Deflections:

Calculated per American Concrete Institute Code 318-08

Assumptions:

$f_y = 40$ ksi
$f'_c = 3$ ksi
$\lambda = 1.0$ (normal weight concrete)
$\xi = 2.0$ (assuming longest period for sustained live load)
30% live load sustained

Shear calculations:

Assumed shear to be $\frac{w_u L}{2}$ for all beams to simplify calculations

Assumed double leg stirrups with #3 (#10 metric) bar size except for B7 where a #4 (#13 metric) stirrup is used to compensate for library loads.

Uniformity in spacing was used primarily with spacings of 10 in. (25 cm) and 7 in (17 cm) for ease in construction. Most spacings were based off of maximum spacings per Code Section 11.4.5.

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Slabs:

Slabs designed for flexure considering maximum negative moments and positive moments using ACI coefficients. Transverse reinforcing for temperature and shrinkage control based on equation:

$$A_{s\,shrinkage} = 0.0018 \times b \times h$$

In both 5 in. (13cm) and 6" (15cm) slabs, reinforcing came out to be based on ρ_{min} for flexure.

B1

	ft
Tributary Width =	8
span =	30

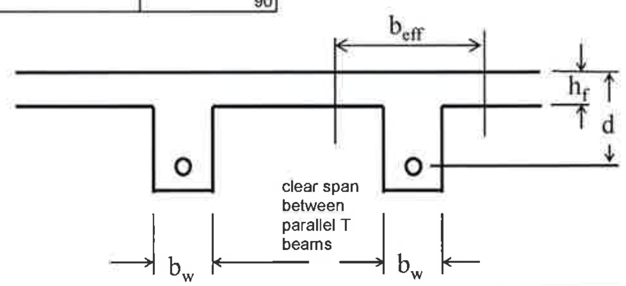
	psf
Live Load =	40
Dead Load =	95

	plf
W_l =	320
W_{dl} =	760

$M_{max\ pin\text{-}pin\ simple\ span}$ =	$(w_u l^2)/8$		
Mu =	$1.2*(M_{Wdl}) + 1.6*(M_{Wll})$	160.2	K-ft

		in
b_{eff} least of:	$16*h_f+b_w$	89
	avg. clear distance to adjacent webs+b_w	105
	span/4	90

f'_c =	3000	psi
f_y =	40000	psi
b_{eff} =	89	in.
b_w =	9	in.
d =	22	in.
h_f =	5	in.
M_u =	160.2	ft-k
β_1 =	0.85	



If a ≤ hf

$R_n = \dfrac{M_u}{\phi b d^2} =$ 49.59 psi. **a < hf so analyse as a rectangular beam**

$\rho = \dfrac{0.85 f'_c}{f_y}\left[1-\sqrt{1-\dfrac{2R_n}{0.85 f'_c}}\right] =$ 0.001252

$a = \dfrac{\rho f_y d}{0.85 f'_c} =$ 0.43205 in.

$c = a/\beta_1 =$ 0.508294

$\varepsilon_t = \dfrac{d-c}{c} 0.003 =$ 0.12684611

$\phi =$ 0.9

$A_s = \rho b d =$ 2.45 in²

$A_{s\,min} = \dfrac{3\sqrt{f'_c}}{f_y} b_w d =$ 0.81 in² ρ_{min}= 0.0041079

$A_{s\,min} = \dfrac{200}{f_y} b_w d =$ 0.99 in² <-- controls ρ_{min}= 0.005

If a > h_f: **a < hf so this analyse is not valid - go to box above**

$A_{sf} = \dfrac{0.85 f'_c (b-b_w) h_f}{f_y} =$ 25.50 in²

$M_{uf} = A_{sf} f_y (d - hf/2) =$ 1491.8 ft - k = 17901 k - in

$M_{uw} = M_{uf} - M_u$ -1331.8 ft - k = -15979 k - in

$R_{nw} = \dfrac{M_{uw}}{\phi b_w d^2} =$ -4075.8

$\rho_w = \dfrac{0.85 f'_c}{f_y}\left[1-\sqrt{1-\dfrac{2R_{nw}}{0.85 f'_c}}\right] =$ -0.06684686

$a = \dfrac{\rho_w f_y d}{0.85 f'_c} =$ -23.069 in.

$c = a/\beta_1 =$ -27.140 in.

$\varepsilon_t = \dfrac{d-c}{c} 0.003 =$ -0.0054 **beam is not ductile - code violation**

$\phi =$ 0.65 **solution is not valid, phi < 0.9**

$A_{sw} = \rho_w b_w d =$ -13.24 in²

$A_s = A_{sw} + A_{sf} =$ 12.28 in²

$A_{s\,min} = \dfrac{3\sqrt{f'_c}}{f_y} b_w d =$ 0.813368 in²

$A_{s\,min} = \dfrac{200}{f_y} b_w d =$ 0.99 in² <-- controls

Note: Solution is based on ϕ = 0.9

As =	2.45
Choose 4# 9	4

(chose 4 bars due to deflection limitations)

Development length			bolt diameter (in)	ld (in)
$l_d/d_b = (f_y*\psi_t*\psi_t)/(20*\lambda*\sqrt{f'_c})$ =		47.469	1.128	53.545
ψt =	1.3			
ψe =	1			
λ =	1			

B1

	Deflection calculator for simply supported, uniformly loaded rectangular beam		
	b =	9	in.
	d =	22	in.
	h =	26	in.
	A_s =	4.00	in^2
	A_s' =	0.00	in^2
	f'_c =	3	ksi
	f_y =	40	ksi
	γ_c =	145	pcf
	λ =	1	
	ξ = (from Table 6.2 or Fig. 6.4)	2.0	
	w_D =	760	plf
	w_L =	320	plf
	ℓ =	30	ft.
Deflection limit (denominator from Table 6.1)		240	
	% live load that is sustained	30	%
	E_c =	3156	ksi
	$n = E_s/E_c$	9.189	9
	ρ =	0.020	
	$n\rho$ =	0.182	
	k =	0.448	
	x =	9.86	in.
	I_{cr} =	8181	in^4
	I_g =	13182	in^4
	f_r =	410.8	psi
	M_{cr} =	34.71	k-ft
Dead + Full Live Load			
	$M_{a,D+L}$ =	121.5	k-ft
	$(M_{cr}/M_{a,D+L})^3$ =	0.0233	
$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1-\left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr} =$		8298.0	in^4
	δ_{D+L} =	0.752	in
Dead Load Only			
	$M_{a,D}$ =	85.5	k-ft
	$(M_{cr}/M_{a,D})^3$ =	0.0669	
	I_e =	8516.0	in^4
	δ_D =	0.515	in.
Live Load Only			
	$\delta_L = \delta_{D+L} - \delta_D$ =	0.236	in.
Initial δ from D + %L			
	$M_{a,D+\%L}$ =	96.3	
	$(M_{cr}/M_{a,D+\%L})^3$ =	0.0468	
	I_e =	8415.6	in^4
	$\delta_{D+\%L}$ =	0.587	in.
Initial δ from %L only			
	$\delta_{\%L} = (\delta_D + \delta_{\%L}) - \delta_D$ =	0.072	in.
Long term δ for D + long term sustained L			
	ρ' =	0	
	$\lambda_{\Delta\infty} = \xi/(1+\rho')$	2.00	
	$\lambda_{\Delta} = \xi/(1+\rho')$	2	
	$\delta_{LT} = \delta_L + \lambda_{\Delta\infty}\delta t_D + \lambda_{\Delta}\delta_{\%L}$ =	1.411	in.
	δ_{Limit} =	1.5	in.
	Deflection complies with Table 6.1		

Shear Design - B1

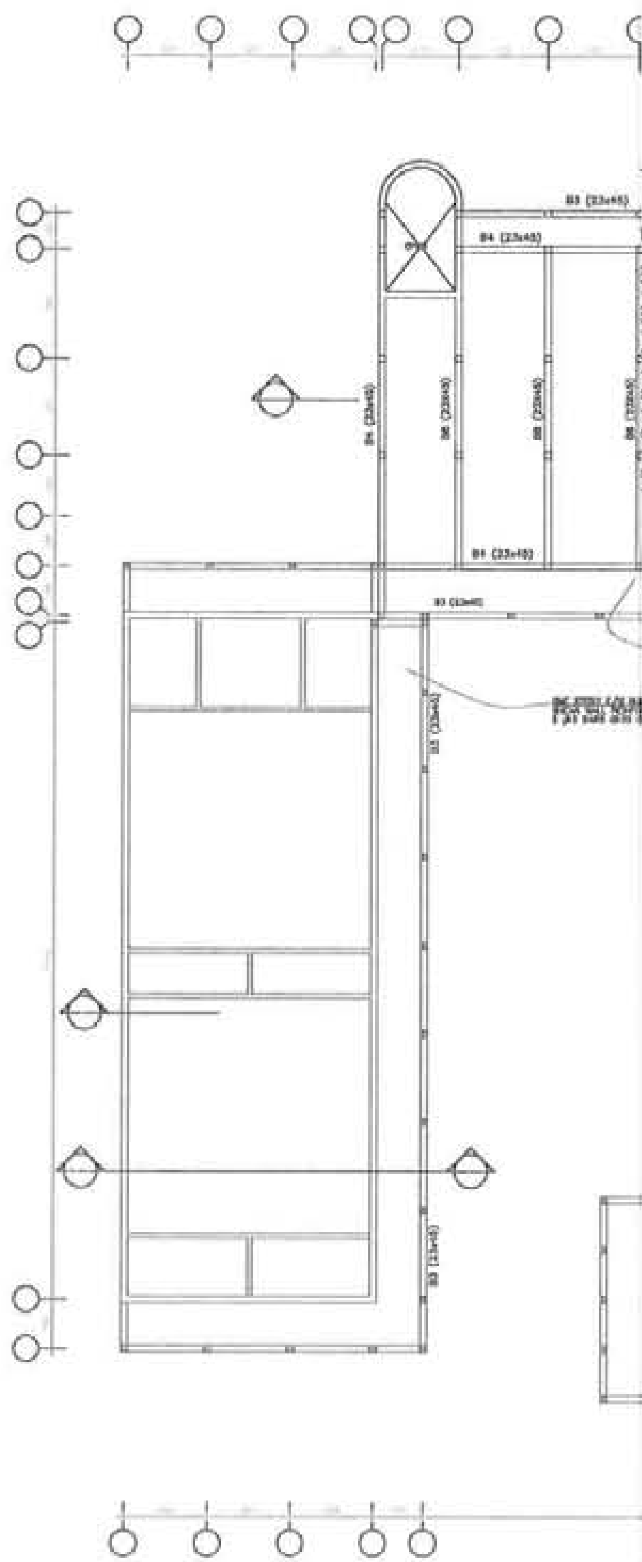
	ft
span =	30

LL =	320	plf
DL =	760	plf
W_u =	1424	plf
Shear at pin =	21360	lb

		Units	
V_u =	21360	lb	
f'_c =	3000	psi	
λ =	1		
b_w =	9	in.	
d =	22	in.	
A_v =	0.22	in^2	(Double leg #3 bar stirrups)
f_{yt} =	40,000	psi	
ϕ =	0.75		
V_c =	21690	lb	
ϕV_c =	16267	lb	
$1/2\phi V_c$ =	8134	lb	
$V_s=(V_u-\phi V_c)/\phi$ =	6790	lb	
Required ϕV_s =	5093	lb	
s =	28.51	in.	
choose s =	10.00	in.	
s_{max} =	11	in.	Code Section 11.4.5
$A_{v\,min}$ =	0.113	in^2	Code Eq. 11-13
s_{max} =	23.80	in.	also Code Eq. 11-13
s_{max} =	19.56	in.	Code Eq. 11-13 with 50 psi limit
Controlling s_{max} =	11.00	in.	
Actual ϕV_s =	14520	ib	
Check ϕV_c-ϕV_s =	30787	lb	

T-Beam Layout

A2.2



n	As	Stirrups	Slab Height (cm)	$As_{flexure}$	As_{temp}
56	4Y29	Y 10 @ 25	13	Y13 @ 25	Y10 @ 20
56	2Y25	Y 10 @ 25	13	Y13 @ 25	Y10 @ 20
45	2Y19	Y 10 @ 17	13	Y13 @ 25	Y10 @ 20
45	2Y19	Y 10 @ 17	15	Y13 @ 25	Y10 @ 17
45	2Y22	Y 10 @ 17	15	Y13 @ 25	Y10 @ 17
45	2Y25	Y 10 @ 15	15	Y13 @ 25	Y10 @ 17

T–BEAM LAYOUT

-18-2010
evisions

Drawing
T-BEAM LAYOUT

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Slab Design

A2.3

5 inch slab for south center

span =	8	ft	
b =	12	in	(designing one foot strip of slab)
d =	3.75	in	(assuming conservative d value)

DL =	95	plf	
LL =	40	plf	
Wu =	178	plf	
Mu $_{max\ negative\ moment}$ =	(1/12) W_uL^2	949.3333	ft-lb
Mu $_{max\ positive\ moment}$ =	(1/14) W_uL^2	813.7143	ft-lb

Mu_{max}/Φbd^2	75.01	psi	
$ρmin_{flexure}$ =	0.005		(for ρmin Mu/Φbd^2 = 192.1 psi)
As = ρ*b*d	0.225	in^2/ft	
#4 @ 8	0.29	in^2/ft	

As shrinkage =	.0018*b*h	0.108	in^2/ft
	#3 @10	0.13	in^2/ft

6 inch slab for south center

span =	11	ft	
b =	12	in	(designing one foot strip of slab)
d =	4.75	in	(assuming conservative d value)

DL =	100	plf	
LL =	125	plf	
Wu =	320	plf	
Mu $_{max\ negative\ moment}$ =	(1/12) W_uL^2	3226.667	ft-lb
Mu $_{max\ positive\ moment}$ =	(1/14) W_uL^2	2765.714	ft-lb

Mu_{max}/Φbd^2	158.90	psi	
$ρmin_{flexure}$ =	0.005		(for ρmin Mu/Φbd^2 = 192.1 psi)
As = ρ*b*d	0.3192	in^2/ft	
#4 @ 7	0.34	in^2/ft	

As shrinkage =	.0018*b*h	0.1296	in^2/ft
	#3 @10	0.13	in^2/ft

Wall Analysis

A3

Flexible Analysis

A3.1

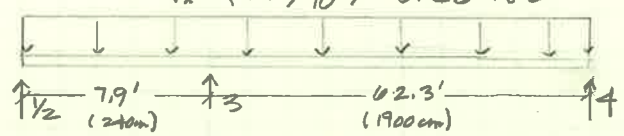
Flexible Diaphragm Analysis

> **Note: Example Calc's**
> • Shear values used to determine reinforcement for one story East/West Bldg's were done in similar manner. Values are found on accompanying Excell Sheet

① NORTHWEST WING: $F_{x(ROOF)} = 20$ KIPS

A:) Seismic direction ↑↓ N or S; WALLS 1/2, 3, & 4

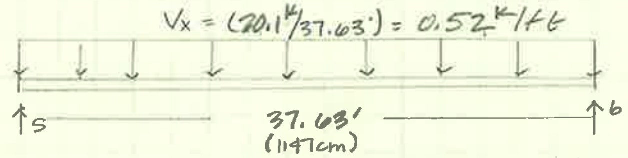
$V_x = (20^k/70') = 0.28^k/ft$



• Wall 1/2 = (1/2 · 7.9') × (0.27 k/ft) = 1.13^k
• WALL 3 = (1.07^k) + 0.27 k/ft (0.5 × 62.3') = 10.07^k
• WALL 4 = 9.09^k

B:) DIRECTION E/W ⇄, WALLS: 5 & 6

$V_x = (20.1^k/37.63') = 0.52^k/ft$

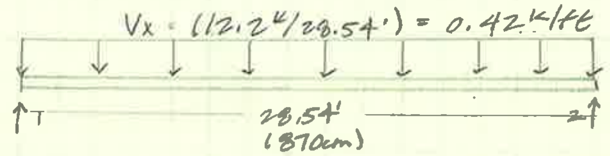


• WALL 5 = (1/2 · 37.63') × (.504 k/ft) = 10.05^k
• WALL 6 = 10.05^k

② CENTER WING @ NORTH: $F_x = 12.2$ KIPS

A:) Wind direction ↑↓ NORTH OR SOUTH; WALLS 1 & 2

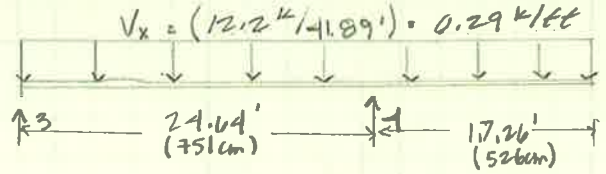
$V_x = (12.2^k/28.54') = 0.42^k/ft$



• WALL 1 = 6.1^k
• WALL 2 = 6.1^k

B:) DIRECTION E/W ⇄; WALLS 3 & 4

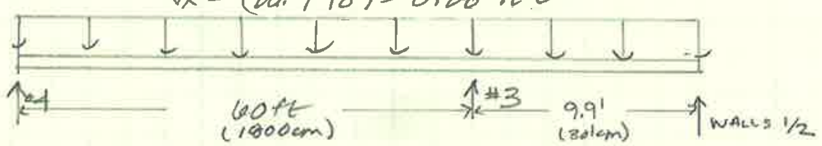
$V_x = (12.2^k/41.89') = 0.29$ k/ft



• WALL 3 = 0.30 k/ft × (.5 · 24.64') = 3.8^k
• WALL 4 = 9.88^k + [0.8 k/ft × (17.26')] = 8.59^k

(3.) A) <u>NORTHEAST WING DUN OES ; WALLS 1-4 ; Fx(ROOF) = 20^k</u>

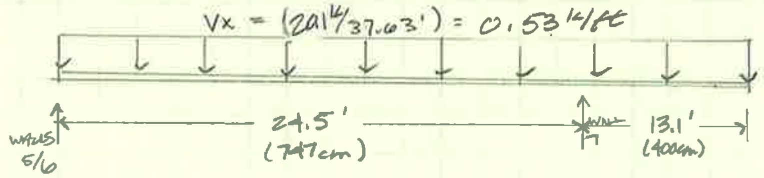
$V_x = (20^k/70') = 0.28^k/ft$



- WALLS 1/2 = ½(9.9') × (0.28^k/ft) = 1.42^k
- WALL #3 = 1.34^k + ½(60)(.28^k/ft) = 10.04^k
- WALL #4 = 8.6^k

(B.) <u>DIRECTION S/W ⇄ ; WALLS 5, 6, & 7</u>

$V_x = (20^k/37.63') = 0.53^k/ft$

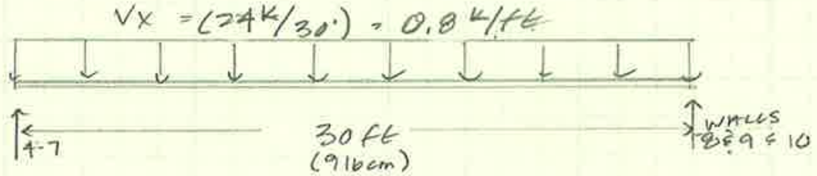


- WALL #5/6 = 6.5^k
- WALL #7 = 13.41^k

(4) <u>CENTERWING : Fx(ROOF) = 24 KIPS</u>

(A) <u>DIRECTION N/S ; WALLS 4 - #9</u>

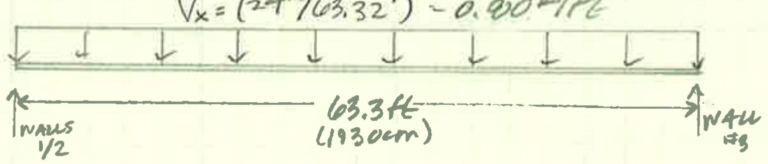
$V_x = (24^k/30') = 0.8^k/ft$



- WALL 4-7 = 12^k ;
- WALLS 8, 9, 10 12^k

(B.) <u>DIRECTION ⇄ S/W; WALLS 1/2 & 3</u>

$V_x = (24^k/63.32') = 0.90^k/ft$



- WALL 1/2 = 12^k
- WALL #3 = 12^k

Sample Calculations: Analysis of SHEAR WALLS

- Shown is typical analysis performed ON ALL SHEAR WALLS:
- Summary OF Analysis is Found ON Excell documents

Rigid Diaphragm analysis performed Via "ENGR CALC". See Attached computer output For Full details.

Summation OF Flexible & Rigid diaphram analysis

I NORTHWEST WING

North/South Direction

Wall	Length (Ft)	V_R (k)	$V_{R(WALL)}$ (k)	$V_{TORSIONAL}$	V_{TOTAL}	$0.7 V_{TOTAL}$
1	7.87	1.13	(1.13 × 7.87)/(7.87 + 3.61) = 0.78	10.95	11.73	8.21
2	3.61	1.13	(1.13 × 3.61)/(7.87 + 3.61) = 0.36	1.81	2.71	1.52
3	12.47	10.08	(10.08)	20.27	30.35	21.24
4	5.58	9.09	(9.09)	7.94	17.03	11.92

(* 7.63": Dimension OF CMU BLOCK)

(* 10.63': height of WALL (h))

Wall	f_v (k/ft²)	f_v (psi)	h/d
1	(8.21)/[7.63" × 1ft/12" × 7.87'] = 1.64	11.39	10.63'/7.87' = 1.35
2	(1.52)/[(7.63" × 1ft/12") × 3.61'] = 0.66	4.59	10.63'/3.61' = 2.95
3	(21.24)/[(7.63" × 1ft/12") × 12.47'] = 2.68	18.61	10.63'/12.47' = 0.85
4	(11.92)/[(7.63" × 1ft/12") × 5.58'] = 3.36	23.24	10.63'/5.58' = 1.91

- Compared values for f_v (Actual shear) to F_v (allowable) per ASCE-07 code.

  $F_v = 25\text{psi}$

- If shear in a given wall exceeded the allowable shear it was determined reinforcement would be necessary. F_v for reinforced shear walls is 75psi. No walls exceeded this allowable value.

- Analysis of all shear walls were done in similiar manner as illustrated above & shear reinforcing calculations & analysis can be found on attached sheets.

Flexible Diaphragm Analysis

NORTHWEST WING

☼ N/S ↓↑ :Walls #1-4; Vx= 20.1 Kips; Wing Length= 70ft

Vx (K/ft)=	0.28714286
Wall	Vx (Kips)
1 & 2	1.13
3	10.08
4	9.09
Σ=	20.30

☼ E/W ↔ :Walls #5&6; Vx= 20.1 Kips; Wing Length= 38ft

Vx (K/ft)=	0.52894737
Wall	Vx (Kips)
5	10.05
6	10.05
Σ=	20.10

NORTHEAST WING

☼ N/S ↓↑ :Walls #1-4; Vx= 20.1 Kips; Wing Length= 70ft

Vx (K/ft)=	0.28714286
Wall	Vx (Kips)
1 & 2	1.42
3	10.04
4	8.61
Σ=	20.07

☼ E/W ↔ :Walls #5-7; Vx= 20.1 Kips; Wing Length= 38ft

Vx (K/ft)=	0.52894737
Wall	Vx (Kips)
5 & 6	6.48
7	13.41
Σ=	19.89

CENTER WING @ NORTH

☼ N/S ↓↑ :Walls #1 & 2; Vx= 12.2 Kips; Wing Length= 29ft

Vx (K/ft)=	0.42068966
Wall	Vx (Kips)
1	6.10
2	6.10
Σ=	12.20

☼ E/W ↔ :Walls #3&4; Vx= 12.2 Kips; Wing Length= 42ft

Vx (K/ft)=	0.29047619
Wall	Vx (Kips)
3	3.58
4	8.59
Σ=	12.17

CENTER WING @ SOUTH

☼ N/S ↓↑ :Walls #4-9; Vx= 24 Kips; Wing Length= 30ft

Vx (K/ft)=	0.8
Wall	Vx (Kips)
4 - 9	12.00
2	12.00
Σ=	24.00

☼ E/W ↔ :Walls #1-3; Vx= 24 Kips; Wing Length= 64ft

Vx (K/ft)=	0.375
Wall	Vx (Kips)
1 & 2	12.00
3	12.00
Σ=	24.00

GROUND FLOOR:EAST/WEST WING

☼ N/S ↓↑ :Walls #1-4; Vx= 12.1 Kips; Wing Length= 30ft

Vx (K/ft)=	0.40333333
Wall	Vx (Kips)
1	6.05
2	6.05
Σ=	12.10

☼ E/W ↔ :Walls #4&5; Vx= 12.1 Kips; Wing Length= 80ft

Vx (K/ft)=	0.52894737
Wall	Vx (Kips)
4 & 5	3.99
3	8.11
Σ=	12.10

Shear Wall Analysis: 1st Floor

NORTHWEST WING

☼ N/S ↓↑ :Walls #1-4

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
1	240	7.87	1.13	0.78	10.95	11.73	8.21	1.64	11.39	1.35	25	N/A
2	110	3.61	1.13	0.36	1.81	2.17	1.52	0.66	4.59	2.95	25	N/A
3	380	12.47	10.08	10.08	20.27	30.35	21.24	2.68	18.61	0.85	25	N/A
4	170	5.58	9.09	9.09	7.94	17.03	11.92	3.36	23.34	1.91	25	N/A

☼ E/W ↔ :Walls #5&6

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
5	230	7.55	10.05	10.05	17.63	27.68	19.38	4.04	28.04	1.41	NO GOOD	75
6	280	9.19	10.05	10.05	20.63	30.68	21.48	3.68	25.53	1.16	NO GOOD	75

NORTHEAST WING

☼ N/S ↓↑ :Walls #1-4

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
1	170	5.58	1.42	0.71	1.48	2.19	1.53	0.43	3.00	1.91	25	N/A
2	170	5.58	1.42	0.71	4.41	5.12	3.58	1.01	7.02	1.91	25	N/A
3	250	8.20	10.04	10.04	8.91	18.95	13.26	2.54	17.66	1.30	25	N/A
4	370	12.14	8.61	8.61	30.21	38.82	27.18	3.52	24.45	0.88	25	N/A

☼ E/W ↔ :Walls #5-7

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
5	160	5.25	6.48	2.53	5.5	8.03	5.62	1.68	11.69	2.03	25	N/A
6	250	8.20	6.48	3.95	13.11	17.06	11.94	2.29	15.90	1.30	25	N/A
7	300	9.84	13.41	13.41	16.35	29.76	20.83	3.33	23.12	1.08	25	N/A

CENTER WING @ SOUTH

☼ N/S ↓↑ :Walls #4-9

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
4	140	4.59	12.00	2.21	2.07	4.28	3.00	1.03	7.12	2.31	25	N/A
5	180	5.91	12.00	2.84	5.61	8.45	5.92	1.58	10.94	1.80	25	N/A
6	220	7.22	12.00	3.47	10.44	13.91	9.74	2.12	14.74	1.47	25	N/A
7	220	7.22	12.00	3.47	10.44	13.91	9.74	2.12	14.74	1.47	25	N/A
8	180	5.91	12.00	6.75	5.48	12.23	8.56	2.28	15.83	1.80	25	N/A
9	140	4.59	12.00	5.25	2.02	7.27	5.09	1.74	12.10	2.31	25	N/A

☼ E/W ↔ :Walls #1-3

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
1	240	7.87	12	6	17.82	23.82	16.67	3.33	23.13	1.35	25	N/A
2	240	7.87	12	6	17.82	23.82	16.67	3.33	23.13	1.35	25	N/A
3	870	28.54	12	12	25.97	37.97	26.58	1.46	10.17018	0.37	25	N/A

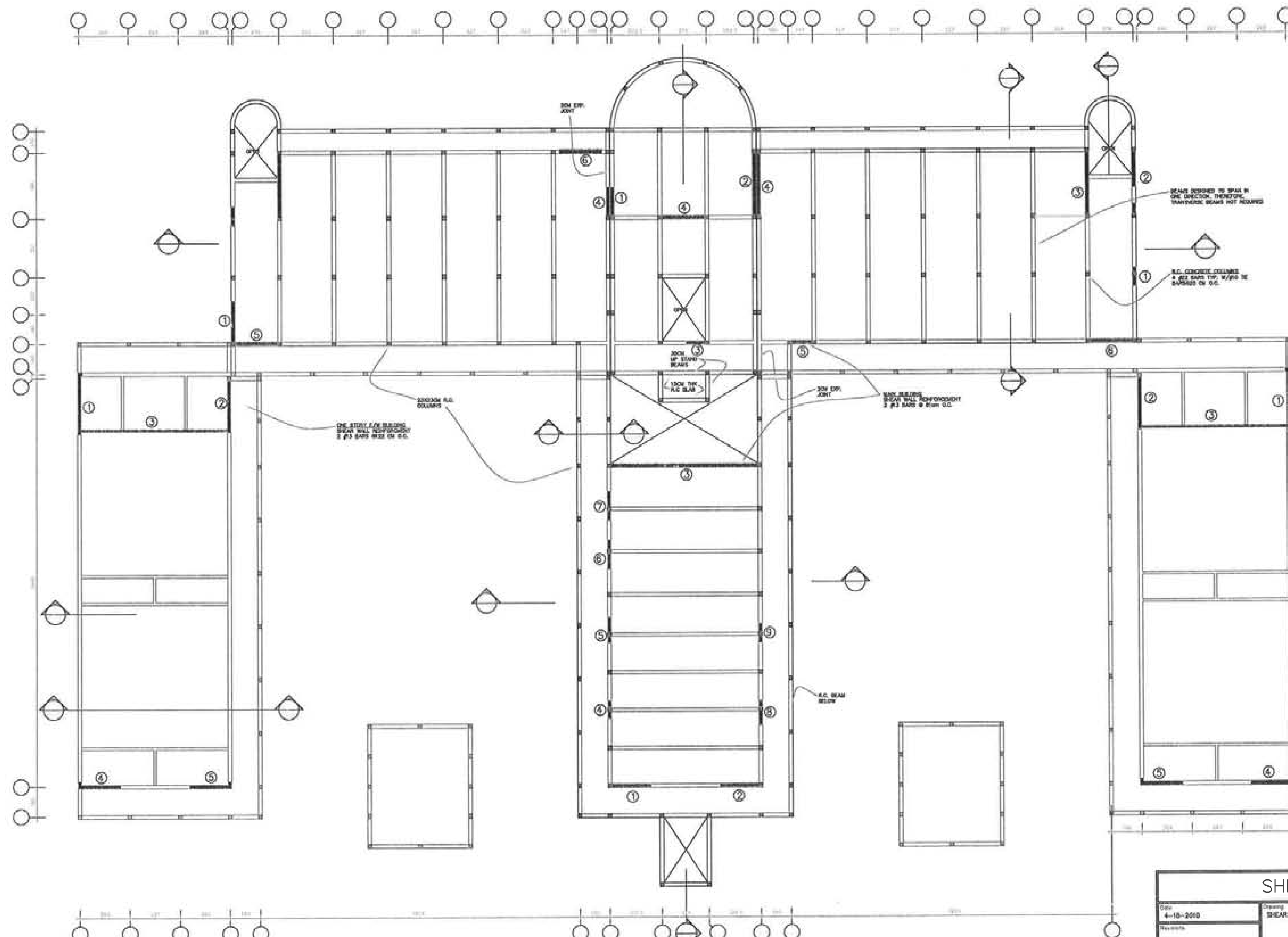
CENTER WING @ NORTH												
☼ N/S ↓↑ :Walls #1&2												
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
1	170	5.58	6.10	6.10	16.22	22.32	15.62	4.41	30.60	1.91	NO GOOD	75
2	370	12.14	6.10	6.10	16.93	23.03	16.12	2.09	14.50	0.88	25	N/A
☼ E/W ↔ :Walls #3&4												
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
3	170	5.58	3.58	3.58	7.63	11.21	7.85	2.21	15.36	1.91	25	N/A
4	250	8.20	8.59	8.59	17.91	26.50	18.55	3.56	24.70	1.30	25	N/A

Ground Floor

EAST & WEST WINGS												
☼ N/S ↓↑ :Walls #1-4												
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
1	340	11.15	6.05	3.03	0.00	3.03	2.12	0.30	2.07	0.95	25	N/A
2	340	11.15	6.05	3.03	0.00	3.03	2.12	0.30	2.07	0.95	25	N/A
☼ E/W ↔ :Walls #5&6												
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	$fv(K/ft^2)$	fv(psi)	(h/d)	Fv (psi)	$Fv_{(reinforced)}$ (psi)
4	258	8.46	3.99	2.00	0	2.00	1.40	0.26	1.80	1.26	25	N/A
5	258	8.46	3.99	2.00	0	2.00	1.40	0.26	1.80	1.26	25	N/A
3	900	29.53	8.11	8.11	0	8.11	5.68	0.30	2.10	0.36	25	N/A

Shear Wall Layout

A3.2



SHEAR WALL LAYOUT

Date	Drawing	
4-15-2010	SHEAR WALL LAYOUT	US
Revisions		
Scale: 1:300		
Drawn: AB		
Approved		

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Shear Wall Reinforcement

A3.3

Sample Calculations: Shear Wall Reinforcement

NORTHWEST WING Wall	Length (ft)	$0.7V_{TOTAL}$ (k)	V/d (k/ft)
1	7.87	8.21	8.21/7.87 = 1.04
2	3.61	1.52	1.52/3.61 = 0.42
3	12.47	21.24	21.24/12.47 = 1.70
4	5.58	11.92	11.92/5.58 = 2.14

- Strength From Shear Reinforcement "V_{SHEAR}"

$$V_{SHEAR} = \frac{\text{Area Steel}}{(\text{Spacing in Feet}) \times F_{steel}}$$

← taken as 20 ksi

example calculation ① 2 #4 BARS @ 32" o.c.

$$V_{SHEAR} = \frac{2(0.20 in^2)}{(32 in \times \frac{1 ft}{12 in}) \times (20 ksi)} = 3.00 \text{ k/ft}$$

- Values of $\frac{V}{d}$ (k/ft) determined the necessary Area of Steel needed for reinforcement. The Number of Bars as well as the spacing can be found for all walls on attached excel spreadsheets.

Shear Wall Reinforcement:

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	0.7(V_{total})	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
NORTHWEST WING														
☼ N/S ↓↑ :Walls #1-4														
1	240	7.87	1.13	0.78	10.95	11.73	8.21	1.04	0.40	0.62	3.00	4.00	3.10	4.65
2	110	3.61	1.13	0.36	1.81	2.17	1.52	0.42	0.40	0.62	3.00	4.00	3.10	4.65
3	380	12.47	10.08	10.08	20.27	30.35	21.24	1.70	0.40	0.62	3.00	4.00	3.10	4.65
4	170	5.58	9.09	9.09	7.94	17.03	11.92	2.14	0.40	0.62	3.00	4.00	3.10	4.65
☼ E/W ↔ :Walls #5&6														
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	0.7(V_{total})	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
5	230	7.55	10.05	10.05	17.63	27.68	19.38	2.57	0.40	0.62	3.00	4.00	3.10	4.65
6	280	9.19	10.05	10.05	20.63	30.68	21.48	2.34	0.40	0.62	3.00	4.00	3.10	4.65
NORTHEAST WING														
☼ N/S ↓↑ :Walls #1-4														
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	0.7(V_{total})	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
1	170	5.58	1.42	0.71	1.48	2.19	1.53	0.27	0.40	0.62	3.00	4.00	3.10	4.65
2	170	5.58	1.42	0.71	4.41	5.12	3.58	0.64	0.40	0.62	3.00	4.00	3.10	4.65
3	250	8.20	10.04	10.04	8.91	18.95	13.26	1.62	0.40	0.62	3.00	4.00	3.10	4.65
4	370	12.14	8.61	8.61	30.21	38.82	27.18	2.24	0.40	0.62	3.00	4.00	3.10	4.65
☼ E/W ↔ :Walls #5-7														
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	0.7(V_{total})	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
5	160	5.25	6.48	2.53	5.5	8.03	5.62	1.07	0.40	0.62	3.00	4.00	3.10	4.65
6	250	8.20	6.48	3.95	13.11	17.06	11.94	1.46	0.40	0.62	3.00	4.00	3.10	4.65
7	300	9.84	13.41	13.41	16.35	29.76	20.83	2.12	0.40	0.62	3.00	4.00	3.10	4.65
CENTER WING @ NORTH														
☼ N/S ↓↑ :Walls #1&2														
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	0.7(V_{total})	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
1	170	5.58	6.10	6.10	16.22	22.32	15.62	2.80	0.40	0.62	3.00	4.00	3.10	4.65
2	370	12.14	6.10	6.10	16.93	23.03	16.12	1.33	0.40	0.62	3.00	4.00	3.10	4.65
☼ E/W ↔ :Walls #3&4														
Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	0.7(V_{total})	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
3	170	5.58	3.58	3.58	7.63	11.21	7.85	1.41	0.40	0.62	3.00	4.00	3.10	4.65
4	250	8.20	8.59	8.59	17.91	26.50	18.55	2.26	0.40	0.62	3.00	4.00	3.10	4.65

CENTER WING @ SOUTH

☼ N/S ↓↑ :Walls #4-9

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
4	140	4.59	12.00	2.21	2.07	4.28	3.00	0.65	0.40	0.62	3.00	4.00	3.10	4.65
5	180	5.91	12.00	2.84	5.61	8.45	5.92	1.00	0.40	0.62	3.00	4.00	3.10	4.65
6	220	7.22	12.00	3.47	10.44	13.91	9.74	1.35	0.40	0.62	3.00	4.00	3.10	4.65
7	220	7.22	12.00	3.47	10.44	13.91	9.74	1.35	0.40	0.62	3.00	4.00	3.10	4.65
8	180	5.91	12.00	6.75	5.48	12.23	8.56	1.45	0.40	0.62	3.00	4.00	3.10	4.65
9	140	4.59	12.00	5.25	2.02	7.27	5.09	1.11	0.40	0.62	3.00	4.00	3.10	4.65

☼ E/W ↔ :Walls #1-3

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 24" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
1	240	7.87	12	6	17.82	23.82	16.67	2.12	0.40	0.62	3.00	4.00	3.10	4.65
2	240	7.87	12	6	17.82	23.82	16.67	2.12	0.40	0.62	3.00	4.00	3.10	4.65
3	870	28.54	12	12	25.97	37.97	26.58	0.93	0.40	0.62	3.00	4.00	3.10	4.65

GROUND FLOOR: EAST/WEST WING

☼ N/S ↓↑ :Walls #1 & 2

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
1	340	11.15	6.05	6.05	0.00	6.05	4.24	0.38	0.40	0.62	3.00	2.00	3.10	4.65
2	340	11.15	6.05	6.05	0.00	6.05	4.24	0.38	0.40	0.62	3.00	2.00	3.10	4.65

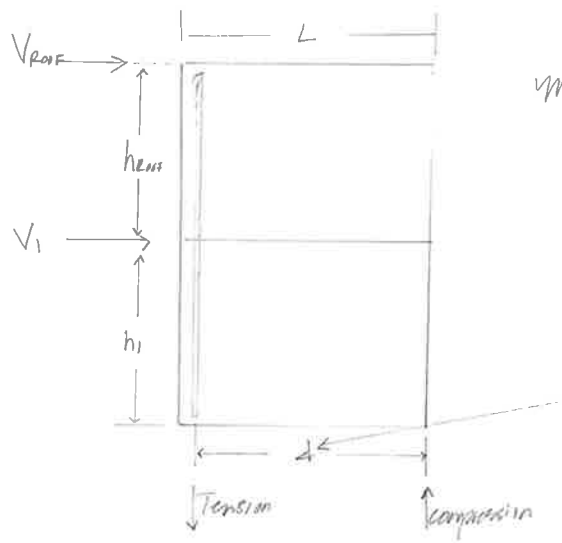
☼ E/W ↔ :Walls #3-5

Wall	Length (cm)	Length (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	V_{total}	$0.7(V_{total})$	V/d(K/ft)	As: 2#4 bars	As: 2#5 bars	V_{shear} 2 #4 bars @ 32" o.c.	V_{shear} 2 #4 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 48" o.c.	V_{shear} 2 #5 bars @ 32" o.c.
4	258	8.46	3.99	0.89	0	0.89	0.62	0.07	0.40	0.62	3.00	2.00	3.10	4.65
5	258	8.46	3.99	0.89	0	0.89	0.62	0.07	0.40	0.62	3.00	2.00	3.10	4.65
3	900	29.53	8.11	8.11	0	8.11	5.68	0.19	0.40	0.62	3.00	2.00	3.10	4.65

Overturning Steel Reinforcement

A3.4

Sample Calculations: Overturning



$$\text{Moment} = V_R(h_2 + h_1) + V_1(h_1)$$

$$T_{ension} = \frac{M}{d} = A_s f_y$$

$$\therefore A_{Steel} = \frac{T}{f_y}$$

"d" = (L - one foot); distance taken from wall's outer face to the centroid of overturning steel; estimated @ length of wall (ft) minus one foot.

Example calculation →

	Wall	Length (ft)	Height (ft)	0.7(V_R)	0.7(V_1)	$M = V_r(2h) + V_1(h)$
Northwest Wing	1	7.87	10.83	0.54	7.67	[(.54)(2)(10.83) + (7.67)(10.83)] = 94.8
	2	3.61	10.83	0.25	1.27	[(.25×2×10.83) + (1.27)(10.83)] = 19.13
	3	12.47	10.83	7.06	14.19	[(7.06)(2)(10.83) + (14.19)(10.83)] = 306.48
	4	5.58	10.83	6.36	5.56	[(6.36×2×10.83) + (5.56×10.83)] = 177.99

	Wall	$M = V_r(2h) + V_1(h)$	Tension = M/d	Area of Steel = T/fy
Northwest Wing	1	94.80	94.8/(7.87'-1') = 13.79	13.79/40ksi = 0.34 in²
	2	19.13	19.1/(3.61'-1') = 7.33	7.33/40ksi = 0.18 in²
	3	306.48	306/(12.47'-1') = 26.73	26.73/40ksi = 0.67 in²
	4	197.99	177.9/(5.58'-1') = 43.25	43.23/40ksi = 1.08 in²

°Remainder of walls were performed similarly. Results can be found on accompanying Excel sheets. Typical areas of steel reinforcement are shown on spreadsheets as a reference for bar sizing.

Overturning Steel Reinforcement:

NORTHWEST WING													
☼ N/S ↓↑ :Walls #1-4													
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension $T=M/d$	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
1	240	7.87	330.00	10.83	1.13	0.78	10.95	0.54	7.67	94.80	13.79	0.34	0.40	0.62
2	110	3.61	330.00	10.83	1.13	0.36	1.81	0.25	1.27	19.13	7.33	0.18	0.40	0.62
3	380	12.47	330.00	10.83	10.08	10.08	20.27	7.06	14.19	306.48	26.73	0.67	0.40	0.62
4	170	5.58	330.00	10.83	9.09	9.09	7.94	6.36	5.56	197.99	43.25	1.08	0.40	0.62
☼ E/W ↔ :Walls #5&6														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension $T=M/d$	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
5	230	7.55	330.00	10.83	10.05	10.05	17.63	7.04	12.34	286.03	43.70	1.09	0.40	0.62
6	280	9.19	330.00	10.83	10.05	10.05	20.63	7.04	14.44	308.77	37.72	0.94	0.40	0.62

NORTHEAST WING														
☼ N/S ↓↑ :Walls #1-4														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension $T=M/d$	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
1	170	5.58	330.00	10.83	1.42	0.71	1.48	0.50	1.04	22.00	4.81	0.12	0.40	0.62
2	170	5.58	330.00	10.83	1.42	0.71	4.41	0.50	3.09	44.21	9.66	0.24	0.40	0.62
3	250	8.20	330.00	10.83	10.04	10.04	8.91	7.02	6.24	219.71	30.51	0.76	0.40	0.62
4	370	12.14	330.00	10.83	8.61	8.61	30.21	6.03	21.15	359.63	32.29	0.81	0.40	0.62
☼ E/W ↔ :Walls #5-7														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension $T=M/d$	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
5	160	5.25	330.00	10.83	6.48	2.53	5.5	1.77	3.85	80.03	18.83	0.47	0.40	0.62
6	250	8.20	330.00	10.83	6.48	3.95	13.11	2.77	9.18	159.29	22.12	0.55	0.40	0.62
7	300	9.84	330.00	10.83	13.41	13.41	16.35	9.39	11.45	327.25	37.01	0.93	0.40	0.62

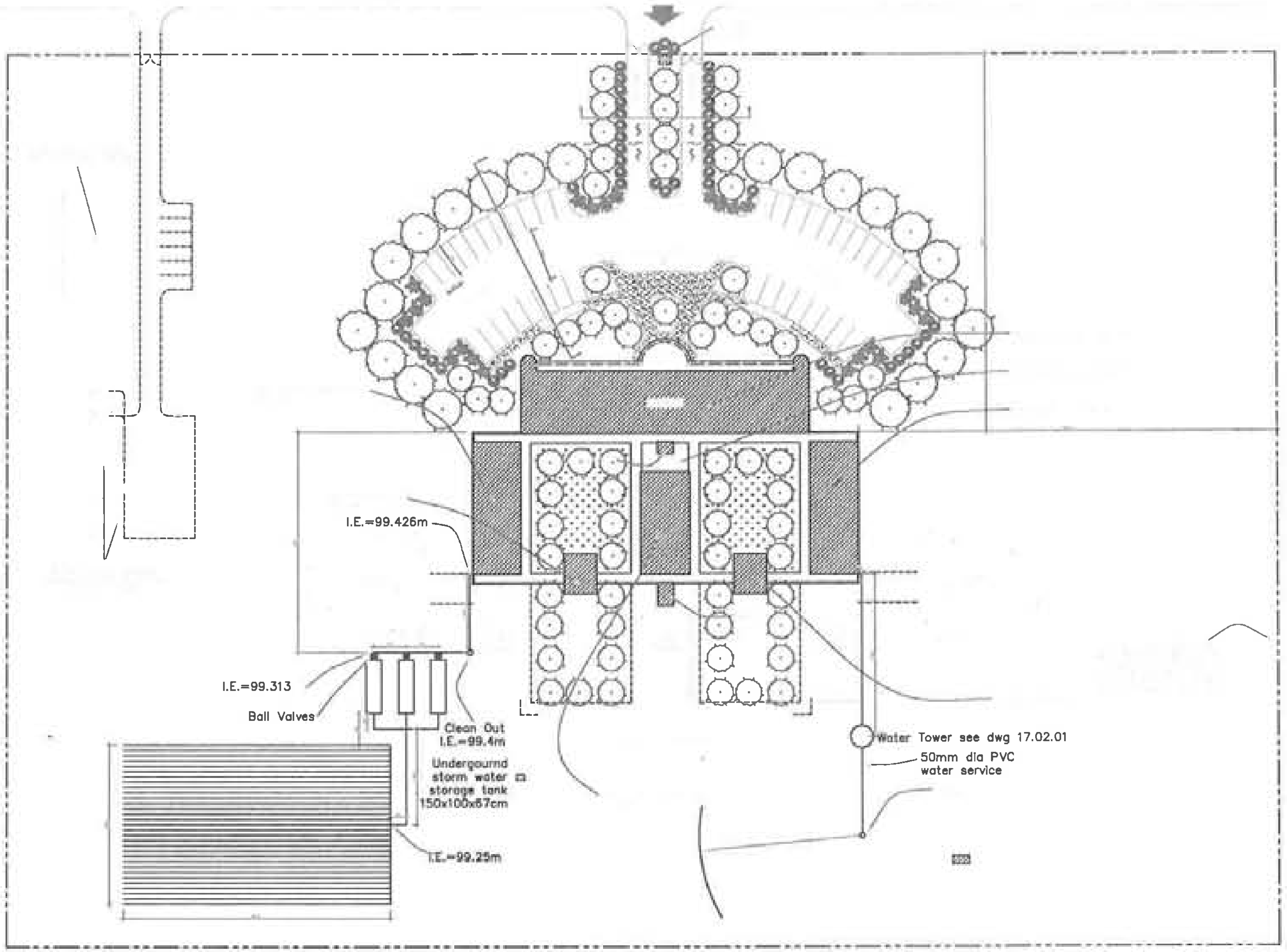
CENTER WING @ SOUTH														
☼ N/S ↓↑ :Walls #4-9														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension T=M/d	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
4	140	4.59	330.00	10.83	12.00	2.21	2.07	1.55	1.45	49.21	13.70	0.34	0.40	0.62
5	180	5.91	330.00	10.83	12.00	2.84	5.61	1.99	3.93	85.62	17.45	0.44	0.40	0.62
6	220	7.22	330.00	10.83	12.00	3.47	10.44	2.43	7.31	131.81	21.20	0.53	0.40	0.62
7	220	7.22	330.00	10.83	12.00	3.47	10.44	2.43	7.31	131.81	21.20	0.53	0.40	0.62
8	180	5.91	330.00	10.83	12.00	6.75	5.48	4.73	3.84	143.89	29.33	0.73	0.40	0.62
9	140	4.59	330.00	10.83	12.00	5.25	2.02	3.68	1.41	94.91	26.42	0.66	0.40	0.62
☼ E/W ↔ :Walls #1-3														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension T=M/d	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
1	240	7.87	330.00	10.83	12	6	17.82	4.20	12.47	226.07	32.89	0.82	0.40	0.62
2	240	7.87	330.00	10.83	12	6	17.82	4.20	12.47	226.07	32.89	0.82	0.40	0.62
3	870	28.54	330.00	10.83	12	12	25.97	8.40	18.18	378.82	13.75	0.34	0.40	0.62

CENTER WING @ NORTH														
☼ N/S ↓↑ :Walls #1&2														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension T=M/d	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
1	170	5.58	330.00	10.83	6.10	6.10	16.22	4.27	11.35	215.45	47.07	1.18	0.40	0.62
2	370	12.14	330.00	10.83	6.10	6.10	16.93	4.27	11.85	220.83	19.83	0.50	0.40	0.62
☼ E/W ↔ :Walls #3&4														
Wall	Length (cm)	Length (ft)	Height (cm)	Height (ft)	V_R	$V_{R(Wall)}$	$V_{W.S.}$	$0.7(V_{R})$	$0.7(V_{W.S.})$	Moment $M=V_r(2h)+V_{w.s}(h)$	Tension T=M/d	Area of Steel $A_s=T/F_y$	As: 2#4 bars	As: 2#5 bars
3	170	5.58	330.00	10.83	3.58	3.58	7.63	2.51	5.34	112.10	24.49	0.61	0.40	0.62
4	250	8.20	330.00	10.83	8.59	8.59	17.91	6.01	12.54	266.05	36.94	0.92	0.40	0.62

Appendix B

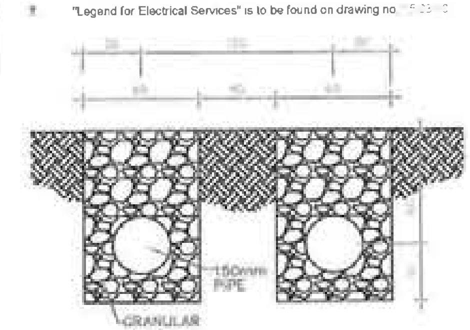
Site Plan

B1



NOTES FOR ELECTRICAL SERVICES:

1. Power connection is to be made to the Building from the nearest main line of the [illegible] at the site using buried armored cable. Contractor is to supply and install all distribution boards, lighting, outlets & any wiring required on site. It is expected that the electrical work will be done be a qualified Electrical Contractor and he is to supply the Architect/Engineer (A/E) with information about size of supply cables and total KVA needed for the building prior to the beginning of any construction for the new electrical supply system. The Contractor is responsible for obtaining all necessary approvals and for payment of all required charges and fees
2. Conduit is to be provided for wiring for all electrical services shown in the drawings and/or as required by the A/E. All conduits are to be concealed
3. Electrical wiring is to be three phased and all outlets are to be grounded. If an outlet is closer than 2 meters to a water source, it is to be a ground fault circuit interrupt (GFCI) outlet
4. The electrical works shall comply with all codes and requirements of the Electric Utility and all wiring shall be executed to pass inspection by an electrical engineer and be made to the full satisfaction of the A/E
5. Fluorescent lighting fittings are generally to be surface-mounted with metal fin diffuser covers or metal hood reflectors
6. All lighting fittings are to be fittings manufactured by "Thorn" company or equal as approved by the A/E
7. "Legend for Electrical Services" is to be found on drawing no [illegible]



NOTES FOR SITE PLAN & SITE WORKS:

1. The Site Plan for this project has been based on a drawing prepared by [illegible]. It is imperative however that the tenderers check the site before tendering as no additions to the contract will be allowed for want of knowledge regarding site conditions or existing structures at the site. Any questions about any buildings to be demolished or retained and about the materials from the demolitions that are to be salvaged for reuse are to be directed to and decided by the Architect/Engineer (A/E). All materials salvaged from demolished buildings are the property of the [illegible] and the values of materials from the existing buildings that are reused in the new construction are to be credited as payment for the cost of construction
2. Generally any expansive (black cotton) soil is to be excavated from the site of all building plus 2 metres all around or as directed by the A/E and is to be removed from the site. All backfilling is to be done in 40 cm lifts and is to be thoroughly compacted after each lift with filling material and methods as approved by the A/E
3. Location of the Building and all other site works shown by the Site Plan are to be verified on site by the A/E. This same applies to building floor levels, slopes of paving areas, plus slopes and depths of drainage channels, etc
4. The Contractor is also to do all new gravel drives, walkways and parking areas which are shown by the Site Plan on this drawing. Topsoil is to be removed from all areas to have new gravel paving to a depth as approved by the A/E and any expansive (black cotton) soil is to be completely removed from such areas plus 1 metre all around such areas. Construction of the gravel surfaced areas shall be as follows: a 250 mm thick consolidated murram base course, graded to falls, is to be applied and soft spots are to be excavated, filled and compacted. A 100 mm finish course of stone quarry waste is then to be laid, leveled to falls and its interstices filled completely with stone dust. The finished roadway is to be rolled with a 6/8 ton roller until no movement is visible under the roller. Walkways are to be similarly made, but the base course of 150 mm and finish course of 50 mm
5. In-ground rainwater drainage channels shown by the Site Plan or elsewhere in this set of drawings are to be made to Standard Detail no. 19.01 with covers as required by the A/E to Standard Detail no. 19.03. In addition, the contractor is to include the cost of 30 running metres of such channels with covers in the cost of construction for drainage to be located as required on site by the Supervisor to provide proper drainage of rainwater around and away from the new building
6. Site Mechanical and Electrical Services are in the contractor's work including rainwater channels, septic tank and drain field etc. The new septic tanks are to be of types and of construction as shown by Standard Drawing no. STD 17.01.01. Locations for the new septic tanks and drain field are shown on the Site Plan and by Mechanical Services Plans in this set of drawings
7. Exact location of site mechanical and electrical services plus location and extent of other site works such as new drives and walkways, channels and ditches for drainage of rainwater are to be decided or verified on location by the A/E
8. Cleaning and leveling of the site is to be completed prior to excavation for placing of building foundations. The A/E is to be consulted before removal of any large trees or bushes, since it is intended to keep existing trees and bushes as much as is possible. Slopes, terraces and embankments resulting from necessary site grading are to be stabilized with plantings of suitable shrubs or ground cover plantings chosen in consultation with the A/E
9. Piping for water services exterior to the buildings is to be installed of sizes and at locations as directed by the A/E
10. "Legend for Drainage Services" on drawing no [illegible] "Notes for Electrical Services" on drawing no [illegible] plus "Notes for Drainage Services" and "Notes for Water Services" on drawing no [illegible] are applicable also for the "Site Plan" on this drawing
11. Site should be graded away from buildings at a 1% slope, or as deemed necessary by the A/E so that water does not collect around the foundations of the buildings

NOTES FOR EXTERIOR FINISHES:

CONCRETE BLOCK WALLS	23 cm masonry exterior walls are to be finished with smooth cement plaster and painted with cement paint
R C COLUMNS & RINGBEAMS:	Are to be finished with smooth cement plaster and painted with cement paint
PRECAST CONCRETE SILLS	Are to be cast smooth & left without further finish
EGDE OF CONCRETE SLABS	Are to be finished with smooth cement plaster and left without further finish
STONE FOUNDATION WALLS:	Are to be pointed with cement mortar and left fairfaced
CONCRETE BLOCK FOUNDATION WALLS	Are to be finished with smooth cement plaster and left without further finish
OUTSIDE FLOORS	Floors of outside verandas are to be finished with 2^5 cm cement screed in natural cement colour
WOOD SLAT SOFFITS & WOOD VERANDAH CEILINGS	Are to be finished with clear varnish or Crown "Timberguard" or equal penetrating wood stain
WOOD FASCIA BOARDS	Are to be painted with supergloss finish oil paint
WOOD DOORS & DOOR FRAMES:	Are to be finished with clear varnish or Crown "Timberguard" penetrating wood stain
METAL CASEMENT WINDOWS, STEEL GATES & SECURITY BARS & HANDRAILS	Are to be painted with super gloss finish oil paint after having been properly treated with primer according to G S before being fixed in the building
PRECAST CONCRETE WALL CAPS:	Are to be cast smooth and left without further finish
METAL ROOFING SHEETS	26 gauge metal roofing sheets and accessories are to be left without further finish

NOTES FOR WATER SERVICES:

1. Water connection to the new Faculties of Arts & Social Sciences is to be made from the nearest main of the new water supply system at the site. The Architect/Engineer (A/E) is to be notified about the source and the capacity of supply to be provided for the water supply system and is to provided with a diagram showing the details of the proposed supply system. The A/E is to review and approved the planned system prior to the beginning of any construction for the new system
2. Depth of pipes in ground should be a minimum of 50 cm
3. Water pipes are to be galvanized steel pipes to BS 1387 medium grade with fittings to BS 143 + 256. Globe stop valves to BS 1010 and gate valves to BS 1952
4. Pipes within buildings are to be dimensioned with major pipes and major branches being 32, 25 & 20 mm pipes. Only smaller branches to be 15 mm pipes. Generally all main pipes are to be kept clear of walls. Minor branch pipes may be concealed in walls according to decision by the Supervisor
5. The A/E is to be consulted about the exact locations of water pipes in the buildings and about any questions relating to the number of taps which are needed. Also 6 cold water taps for hose connection are to be installed at exterior of building at locations as decided upon by the A/E
6. Connections for water services are to be made to all sinks, toilets and hand basins shown on "Mechanical Services Plan" on this drawing plus to the six outside taps
7. Water services are to be made with all necessary taps, valves, stop valves and other required fittings. Taps are to be 'Cobra' or 'Bricon' brand or approved equal
8. There are to be 5 nos 1000 litre capacity galvanized steel or plastic cold water cisterns with covers of manufacture as approved by the A/E located on ceiling slabs at locations as shown by the "Mechanical Services Plan" [illegible]. Cisterns are to have ball valves for over flow shutoff to BS 1212
9. References to BS in Legends or Notes refer to "British Standards for Building"
10. "Legend for Sanitary Fittings" is to be found [illegible]. No "ex-China" Sanitary fittings are acceptable and fittings are to be "ex-India" or approved equal

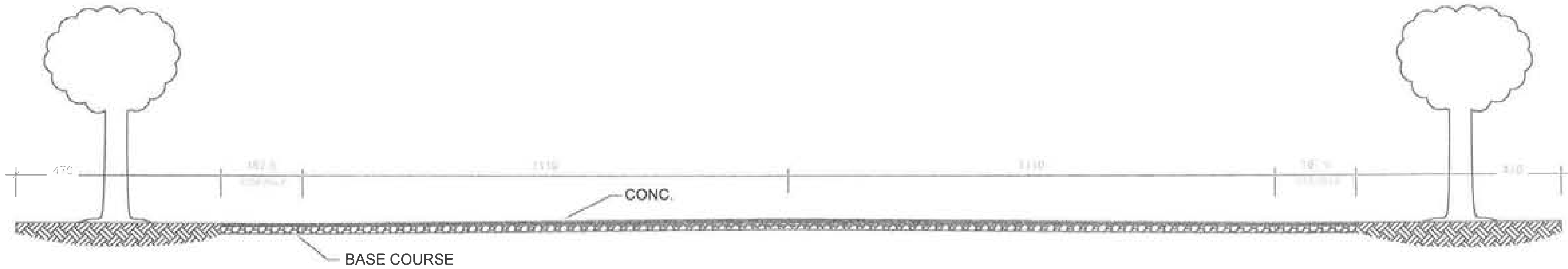
NOTES FOR DRAINAGE SERVICES:

1. Sewerage is to be connected to 3 new [illegible] made to Standard Drawing no 17 01 01 and drain field at locations as shown by the "Site Plan" on drawing no [illegible]
2. Site sewerage services are shown on the "Mechanical Services Plan" on drawing no [illegible]. Minimum slope on pipes - 20 o/oo. Exact locations of sewerage services are to be verified on site by the Architect/Engineer (A/E). Sewer service will be 150mm pvc sewer pipe
3. Laterals for drain field are to be 150 mm dia Pvc with min 1 m spacing between laterals, and a slope of 00179 m/m
4. [illegible]
5. Drainage channels for surface water may be required by the A/E and are to be made to Standard Detail No 19.01 with any necessary covers to Standard Detail No. 19 03. The Supervisor is to verify the location and extent of all such channels on site
6. Drainage swales or ditches are to be made alongside the buildings, roadways and walkways as required by the A/E and are to be sloped to drain to existing rainwater drainage alongside the building site.
7. See also "Notes for Site Works and Site Plan" on drawing no [illegible]
8. "Legend for Drainage Services" is to be found on drawing no [illegible]

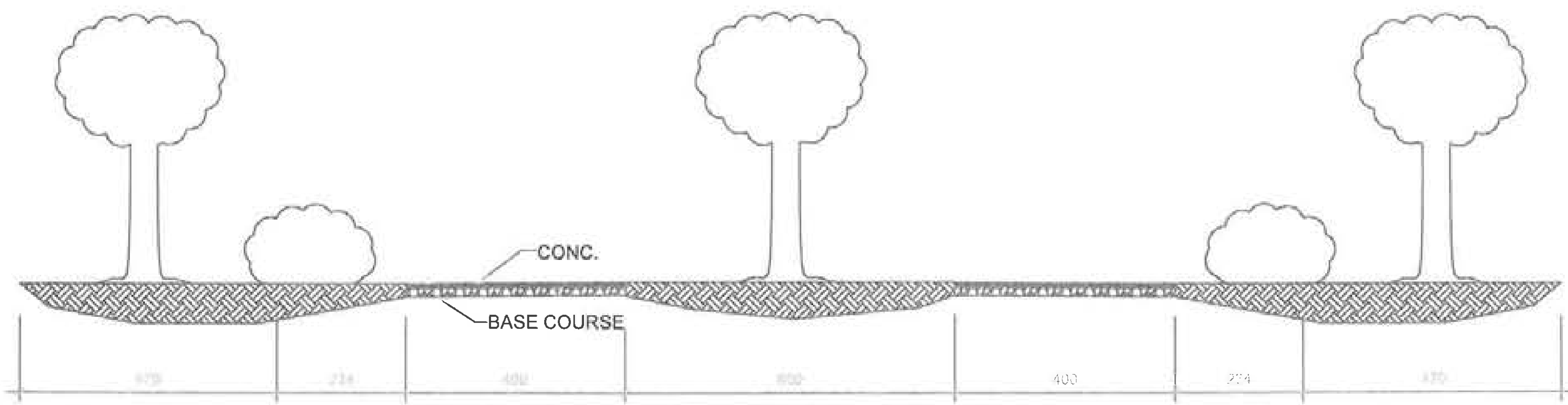
MSAADA

Driveway Cross Sections

B1.1



A-A PARKINGLOT



B-B DRIVEWAY

MSAADA

Specifications

B2

PACKAGED PUMP, GENERATOR, AND PHOTO VOLTAIC SYSTEMS

PART 1 – GENERAL

I. RELATED DOCUMENTS

A. Drawings and general provisions from the MSAADA General Specifications apply to this section

II. SUMMARY

A. The work covered in this section consists of providing a complete and functional packaged sewage pumping station in accordance with the project drawings and these specifications.

B. The packaged systems shall be complete in all respects, and shall include associated hardware and controls at locations indicated on the project drawings.

C. The prefabricated packaged groundwater pump shall be manufactured by Grundfos Pumps, Co. , the PV systems by Evergreen Solar, and the generator by Caterpillar, or an approved equal.

III. GROUNDWATER PUMP (Appendix B2-1)

A. Shall be submersible pump; model 5 SQ07-230 as manufactured by Grundfos Pump, Co. or an approved equal.

B. The pump shall be rated at 1.542 H.P., 1 x 200-240 volts, single phase, 60 hertz, 10700 R.P.M. The pump shall have a 2-inch discharge. Pump curve shall be as follows:

1. 6 gpm at 218 ft TDH.
2. 4 gpm at 309 ft TDH.
3. 2 gpm at 365 ft TDH.
4. Shutoff head at 43 plus or minus ft.

C. Pump shall be non-overloading and capable of being run dry or at low heads for extended periods of time.

IV. GENERATOR (Appendix B2-2)

A. Shall be diesel generator model D125-6 (3-Phase) as manufactured by Caterpillar or an approved equal.

B. The generator shall be rated at 125-150 kW (156.3-187.5 kVA) standby and 114-135 kW

(142.5-168.8 kVA) prime, 120/240V, 3 phase, 60 hertz, minimum ambient temperature 85 degrees Celsius.

V. PHOTO VOLTAIC (SOLAR) (Appendix B2-3)

A. Shall be a PV grid tie system with battery backup, model VES 2550 as packaged by Veterans Energy Solutions, LLC or an approved equal.

B. System must include solar panels with capable of at least 22550 watts of energy, PVC W/P junction box, 60A DC circuit breaker, and all mounting hardware necessary.

VI. WATER CISTERNS (Appendix B2-4)

A. Shall be 1000 liters in size and made of food grade safe FDA approved polyethylene plastic or an approved equal.

B. The approximate dimensions shall be 80 cm in diameter and 216 cm high, with a 20 cm vented manway, 2.5 cm inlet, and 3.8 cm outlet.

Pump Specifications

B2.1

96160133 5 SQ07-230 60 Hz

Input

Select Application

	Groundwater supply
Overview mode	No

Select Type of Installation

	Well installation, closed tank
Installation Type	Bore hole

Your Requirements

Allowed flow oversize	30 %
Allowed flow undersize	0 %
Flow	5.55 US gpm
Head	240 ft
Maximum water temperature	70 °F
Operating hours per day (low)	10 h
Speed regulation	No

Configuration

Motor selection	Grundfos standard motor
Pump material	GG 0.6025 or 1.4301 (AISI 304)

Operational Conditions

Calculation period	15 years
Energy price (high)	0.20 $/kWh
Energy price (low)	0.07 $/kWh
Energy price (medium)	0.12 $/kWh
Evaluation criterion	Electricity consumption
Frequency	60 Hz
Increase of energy price	6 %
Phase	1 or 3
Starting method 3-phase	DOL

Hit list settings

Maximum number of results	20
Pumps per product proup	1

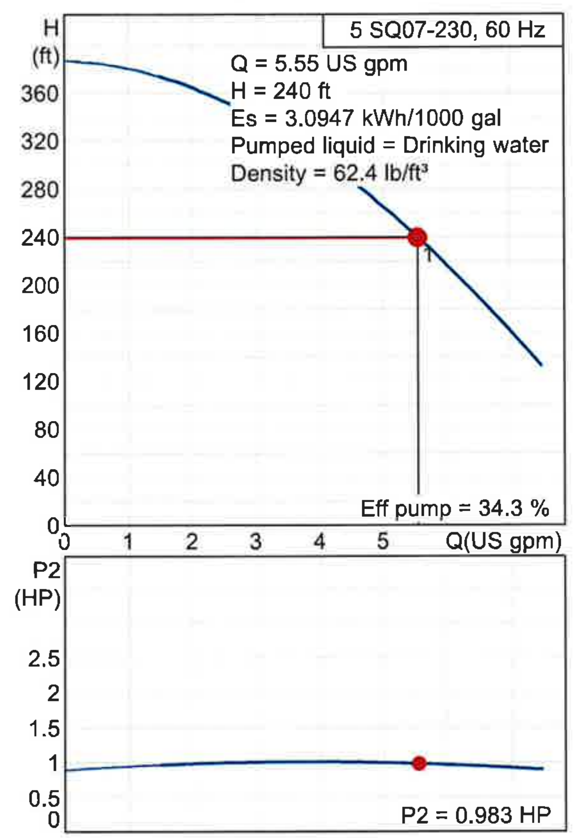
Load profile

	1	
Flow	100	%
Head	100	%
Time	3650	h/Year
Consumption	3768	kWh/Year

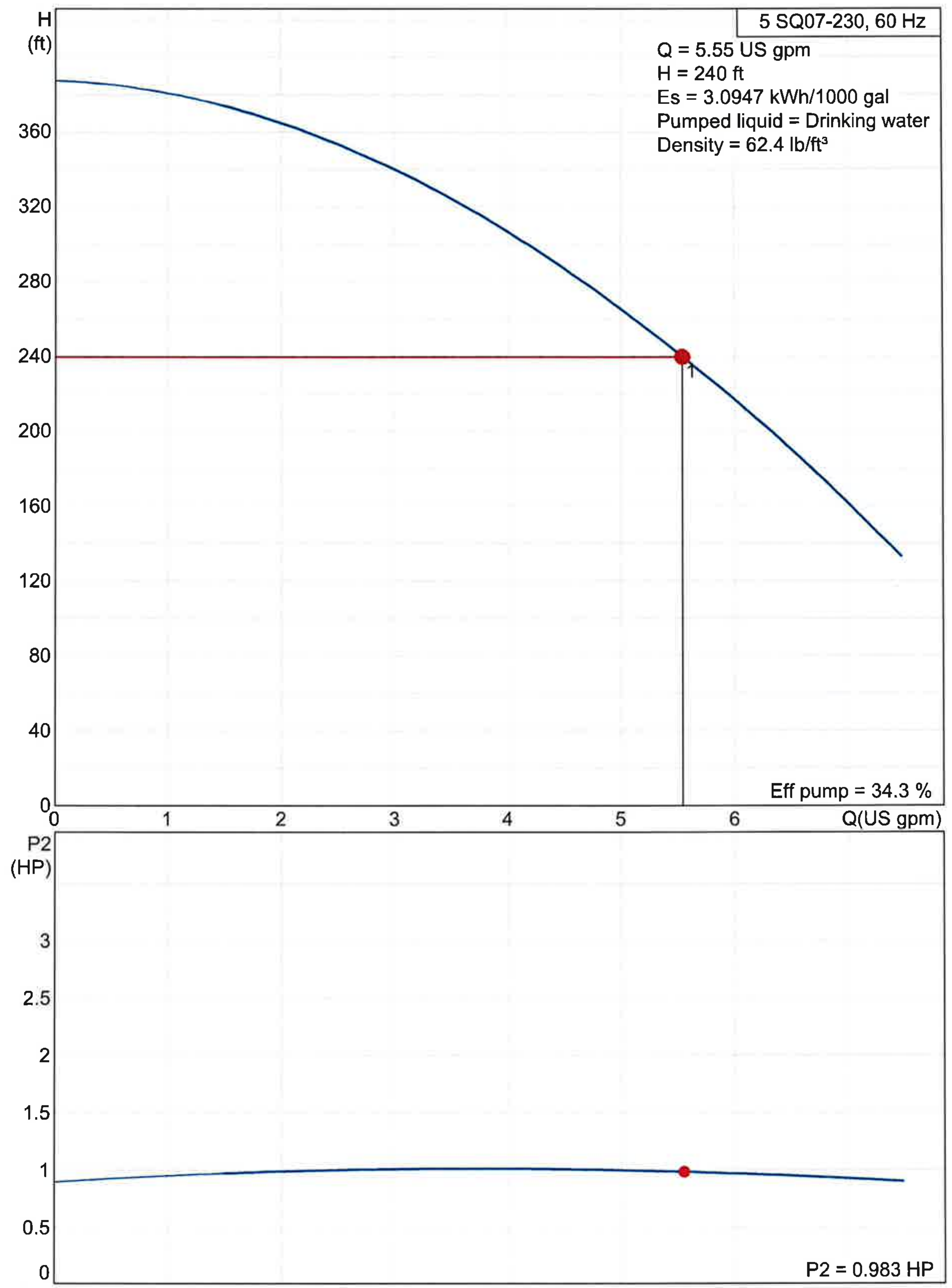
Sizing result

Type	5 SQ07-230	
Quantity * Motor	1 * 1.542 HP , 200-240 V	
Flow	5.56	US gpm
H total	240	ft
Power P1	1.03	kW
Power P2	0.982	HP
Current (rated)	8.4	A
Cos phi (actual)	1.00	
Eff pump	34.3	%
Eff motor	71.0	%
Eff total	24.4	% =Eta pump * Eta motor
Flow total	1215056	gal/year
Spec. consumpt.	3.101	kWh/1000 gal
	9.9	kWh/gal/ft
Consumption	3768	kWh/Year
Price	$ On request	
Energy cost	$ 264	/Year
Total costs	$ On request	/15Years

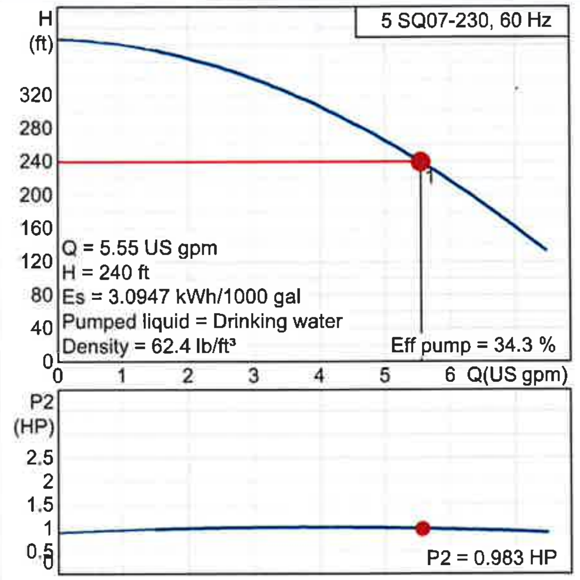
Cable losses not included!

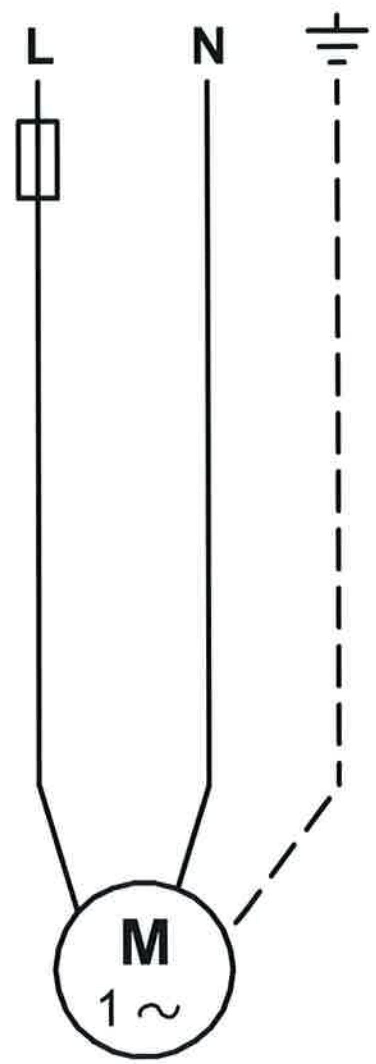


96160133 5 SQ07-230 60 Hz



Description	Value
Product name:	5 SQ07-230
Product No.:	96160133
EAN:	5700398693628
Technical:	
Speed for pump data:	10700 rpm
Actual calculated flow:	5.56 US gpm
Resulting head of the pump:	240 ft
Approvals on nameplate:	UL, cUL
Approvals on motor nameplate:	CE,UL,CUL
Curve tolerance:	ISO 9906 Annex A
Pump Number:	96397363
Stages:	5
Model:	B
Valve:	pump with built-in non-return valve
Materials:	
Pump:	Polyethylene / Stainless steel DIN W.-Nr. 1.4301
Motor:	Stainless steel DIN W.-Nr. 1.4301 AISI 304
Installation:	
Min inlet pressure:	-8.4 psi
Pump outlet:	NPT 1
Minimum borehole diameter:	2.99 in
Liquid:	
Pumped liquid:	Drinking water
Maximum liquid temperature:	95 °F
Max liquid temperature at 0.15 m/sec:	95 °F
Density:	62.4 lb/ft³
Electrical data:	
Motor type:	MS3
Power input - P1:	1.65 kW
Rated power - P2:	1.542 HP
Main frequency:	60 Hz
Rated voltage:	1 x 200-240 V
Start. method:	direct-on-line
Service factor:	2,05
Rated current:	8.4 A
Power factor:	1,00
Rated speed:	10700 rpm
Enclosure class (IEC 34-5):	58
Insulation class (IEC 85):	F
Motor protection:	Y
Thermal protec:	internal
Length of cable:	4.922 ft
Motor Number:	96160536
Controls:	
CU 300/CU 301:	no communication possible
Others:	
Sales region:	Namreg

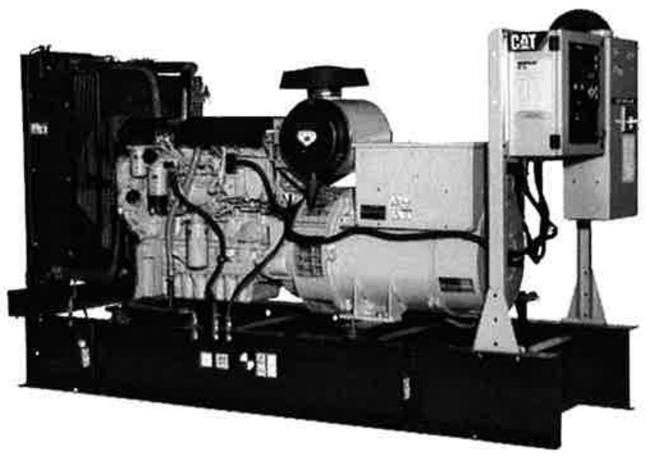




Generator Specifications

B2.2

DIESEL GENERATOR SET CATERPILLAR®



Picture shown may not reflect actual package

STANDBY 125-150 kW
PRIME 114-135 kW
60 Hz

Model	Standby kW (kVA)	Prime kW (kVA)
D125-6	125 (156.3)	114 (142.5)
D150-8	150 (187.5)	135 (168.8)

Tier 3 EPA Approved, Emissions Certified

FEATURES

GENERATOR SET
- Complete system designed and built at ISO 9001 certified facilities
- Factory tested to design specifications at full load conditions

ENGINE
- Governor, electronic
- Electrical system, 12 VDC
- Cartridge type filters
- Battery rack and cables
- Coolant and lube drains piped to edge of base

GENERATOR
- Insulation system, class H
- Drip proof generator air intake (NEMA 2, IP23)
- Electrical design in accordance with BS5000 Part 99, EN61000-6, IEC60034-1, NEMA MG-1.33

CONTROL SYSTEM
- EMCP 3.1 digital control panel
- Vibration isolated NEMA 1 enclosure with lockable hinged door
- DC and AC wiring harnesses

MOUNTING ARRANGEMENT
- Heavy-duty fabricated steel base with lifting points
- Anti-vibration pads to ensure vibration isolation
- Complete OSHA guarding
- Stub-up pipe ready for connection to silencer pipework
- Flexible fuel lines to base with NPT connections

COOLING SYSTEM
- Radiator and cooling fan complete with protective guards
- Standard ambient temperatures up to 50° C (122° F)

CIRCUIT BREAKER
- UL/CSA listed
- 3-pole with solid neutral
- NEMA 1 steel enclosure, vibration isolated
- Electrical stub-up area directly below circuit breaker

AUTOMATIC VOLTAGE REGULATOR
- Voltage within ± 0.5% 3-phase at steady state from no load to full load
- Provides fast recovery from transient load changes

EQUIPMENT FINISH
- All electroplated hardware
- Anticorrosive paint protection
- High gloss polyurethane paint for durability and scuff resistance

QUALITY STANDARDS
- BS4999, BS5000, BS5514, EN61000-6, IEC60034, NEMA MG-1.33, NFPA 110 (with optional equipment)

DOCUMENTATION
- Operation and maintenance manuals provided
- Wiring diagrams included

WARRANTY
- All equipment carries full manufacturer's warranty.

OPTIONAL EQUIPMENT*

ENCLOSURE
- B Series weather protective enclosure (includes internal silencer system)
- Sound attenuated enclosure (includes internal silencer system)
  - Single point lift
  - Panel viewing window
  - External emergency stop pushbutton

SILENCER SYSTEM – OPEN UNIT
- Level 1 silencer
- Level 2 silencer
- Level 3 silencer
- Mounting kit
- Through-wall installation kits

ENGINE
- Battery heater
- Lube oil drain pump
- High lube oil temperature shutdown
- Lube oil sump heater

CIRCUIT BREAKER
- Auxiliary voltfree contacts
- Shunt trip

GENERATOR
- Anti-condensation heater
- Permanent magnet generator
- AREP excitation system
- Generator upgrade 1 size

CONTROL SYSTEM
- No control system
- EMCP 3.2 digital control panel

MOUNTING ACCESSORIES
- Seismic (Zone 4) vibration isolators

FUEL SYSTEM
- UL listed closed top-diked skid-mounted fuel tank base (12/24-hour capacity) with fuel alarm (low level/leak detected)
- Critical high fuel alarm
- Critical low fuel level shutdown

COOLING SYSTEM
- Coolant heater
- Low coolant temperature alarm
- Low coolant level shutdown
- Radiator transition flange

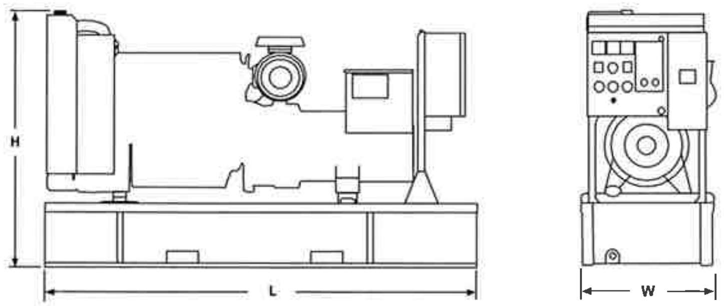
REMOTE ANNUNCIATORS
- 16-channel remote annunciator panel (supplied loose)

MISCELLANEOUS ACCESSORIES
- Toolkit
- Additional operator's manual pack
- Special enclosure color
- UL listing
- CSA certification
- French or Spanish language labels

EXTENDED SERVICE CONTRACTS
- Extended Service Coverage available

* Some options may not be available on all models.
Not all options are listed.

GENERATOR SET DIMENSIONS AND WEIGHTS



Model	Length mm (in)	Width mm (in)	Height mm (in)	Weight kg (lb)*
D125-6	2780 (109.4)	900 (35.4)	1543 (60.7)	1347 (2,970)
D150-8	2780 (109.4)	900 (35.4)	1543 (60.7)	1407 (3,102)

NOTE: General configuration not to be used for installation. See specific dimensional drawings for detail.

*Includes oil and coolant

CATERPILLAR®

SPECIFICATIONS

GENERATOR

Voltage regulation .... ± 0.5% 3-phase at steady state from no load to full load
Frequency ..... ± 0.25% for constant load, no load to full load
Waveform distortion .... THD < 4%, at no load
Radio interference .... Compliance with EN61000-6
Telephone interference.................. TIF < 50, THF < 2%
Overspeed limit................................. 2250 rpm
Insulation... Class H
Temperature rise .... Within Class H limits
Available voltages 277/480, 266/460, 120/240, 127/220, 120/208, 347/600
Deration .... Consult factory for available outputs
Ratings .... At 30° C (86° F), 152.4 m (500 ft), 60% humidity, 0.8 pf

ENGINE

Manufacturer.................................. Caterpillar
Type 4-cycle
Bore – mm (in) 105.0 (4.13)
Stroke – mm (in).............................. 127.0 (5.00)
Governor Type .... Electronic
Class... G2
Piston speed – m/sec (ft/sec)..................... 7.62 (25.0)
Engine speed – rpm 1800
Air cleaner type .... Dry, replaceable paper element type with restriction indicator

D125-6 – C6.6 ACERT

Aspiration .... ATAAC
Cylinder configuration............................ In-line 6
Displacement – L (cu in).......................... 6.6 (404)
Compression ratio 16.3:1
Max power at rated rpm – kW (hp)
Standby..................................... 161.6 (217)
Prime 144.6 (194)
BMEP – kPa (psi)
Standby 1633 (237)
Prime....................................... 1461 (212)
Regenerative power – kW (hp)..................... 14.9 (20)

D150-8 – C6.6 ACERT

Aspiration .... ATAAC
Cylinder configuration............................ In-line 6
Displacement – L (cu in).......................... 6.6 (404)
Compression ratio 16.3:1
Max power at rated rpm – kW (hp)
Standby..................................... 171.3 (230)
Prime 154.4 (207)
BMEP – kPa (psi)
Standby 1731 (251)
Prime....................................... 1560 (226)
Regenerative power – kW (hp)..................... 14.9 (20)

CONTROL PANEL

- Heavy duty sheet steel enclosure with lockable hinged door
- Vibration isolated from generating set
- LCD display
- AC metering
- DC metering
- Fail to start shutdown
- Low oil pressure shutdown
- High engine temperature
- Low/high battery voltage
- Underspeed/overspeed
- Loss of engine speed detection
- 2 spare fault channels
- 20 event fault log
- 2 LED status indicators
- Lockdown emergency stop push button

RATING DEFINITIONS AND CONDITIONS

Standby – Applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings. The generator is peak rated (as defined in ISO8528-3).

Prime – Applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power. There is no limitation to the annual hours of operation and the generator set can supply 10 percent overload power for 1 hour in 12 hours.

CATERPILLAR®

D125-6 (3-Phase)

Materials and specifications are subject to change without notice.

Generator Set Technical Data – 1800 rpm/60 Hz			Standby		Prime	
Power Rating	kW	kVA	125	156.3	114	142.5
Lubricating System						
Type: full pressure						
Oil filter: spin-on, full flow						
Oil cooler: watercooled						
Oil type required: API CH4/CI4						
Total oil capacity	L	U.S. gal	16.5	4.4	16.5	4.4
Oil pan	L	U.S. gal	15.5	4.1	15.5	4.1
Fuel System						
Generator set fuel consumption						
100% load	L/hr	gal/hr	40.6	10.7	36.0	9.5
75% load	L/hr	gal/hr	31.6	8.3	30.0	7.9
50% load	L/hr	gal/hr	24.5	6.5	23.2	6.1
Engine Electrical System						
Voltage/ground: 12/negative						
Battery charging generator ampere rating	amps		100		100	
Cooling System						
Water pump type: centrifugal						
Radiator system capacity incl. engine	L	U.S. gal	21.0	5.5	21.0	5.5
Maximum coolant static head	m H_2O	ft H_2O	8.0	26.0	8.0	26.0
Coolant flow rate	L/hr	U.S. gal/hr	10 200	2,693	10 200	2,693
Minimum temperature to engine	°C	°F	85	185	85	185
Temperature rise across engine	°C	°F	7.9	14.2	7.9	14.2
Heat rejected to coolant at rated power	kW	Btu/min	74.9	4,262	69.8	3,971
Total heat radiated to room at rated power	kW	Btu/min	13.0	740	12.1	688
Radiator fan load	kW	hp	8.0	10.7	8.0	10.7
Air Requirements						
Combustion air flow	m³/min	cfm	12.6	445	12.3	434
Maximum air cleaner restriction	kPa	in H_2O	5	20	5	20
Radiator cooling air (zero restriction)	m³/min	cfm	327	11,548	327	11,548
Generator cooling air	m³/min	cfm	26.4	923	26.4	923
Allowable air flow restriction (after radiator)	kPa	in H_2O	0.12	0.50	0.12	0.50
Cooling air flow (@ rated speed)						
Rate with restriction	m³/min	cfm	317	11,195	317	11,195
Exhaust System						
Maximum allowable backpressure	kPa	in Hg	15	4.4	15	4.4
Exhaust flow at rated kW	m³/min	cfm	29.7	1,049	28.6	1,010
Exhaust temperature at rated kW –						
Dry exhaust	°C	°F	437	819	427	801
Generator Set Noise Rating* (without attenuation) at 1 m (3 ft)	dB(A)		97		97	

Generator Technical Data		277/480V	266/460V	127/220V	120/240V 120/208V	347/600V
Motor Starting Capability: (30% voltage dip)	(kVA)					
	Self excited	360	335	311	283	N/A
	PM excited**	469	437	406	370	437
	AREP excited	469	437	406	370	437
Full Load Efficiencies:	Standby	92.7	92.6	92.5	92.3	92.6
	Prime	92.8	92.8	92.7	92.5	92.8
Reactances (per unit):	X_d	2.74	2.99	3.27	3.65	2.99
	X'_d	0.10	0.10	0.11	0.13	0.10
Reactances shown are applicable to the standby rating.	X''_d	0.057	0.062	0.068	0.076	0.062
	X_q	1.65	1.79	1.96	2.19	1.79
	X''_q	0.068	0.074	0.080	0.090	0.074
	X_2	0.063	0.068	0.075	0.083	0.068
	X_0	0.004	0.005	0.005	0.006	0.005
Time Constants:		t'_d 100 ms	t''_d 10 ms	t'_{do} 2865 ms	t_a 15 ms	

* dB(A) levels are for guidance only
** With PMG Excited Option AVR12

CATERPILLAR®

D150-8 (3-Phase)

Materials and specifications are subject to change without notice.

Generator Set Technical Data – 1800 rpm/60 Hz			Standby		Prime	
Power Rating	kW	kVA	150	187.5	135	168.8
Lubricating System						
Type: full pressure						
Oil filter: spin-on, full flow						
Oil cooler: watercooled						
Oil type required: API CH4/CI4						
Total oil capacity	L	U.S. gal	16.5	4.4	16.5	4.4
Oil pan	L	U.S. gal	15.5	4.1	15.5	4.1
Fuel System						
Generator set fuel consumption						
100% load	L/hr	gal/hr	44.7	11.8	41.5	11.0
75% load	L/hr	gal/hr	36.8	9.7	34.3	9.1
50% load	L/hr	gal/hr	28.4	7.5	26.6	7.0
Engine Electrical System						
Voltage/ground: 12/negative						
Battery charging generator ampere rating	amps		100		100	
Cooling System						
Water pump type: centrifugal						
Radiator system capacity incl. engine	L	U.S. gal	21.0	5.5	21.0	5.5
Maximum coolant static head	m H_2O	ft H_2O	8.0	26.0	8.0	26.0
Coolant flow rate	L/hr	U.S. gal/hr	10 200	2,693	10 200	2,693
Minimum temperature to engine	°C	°F	85	185	85	185
Temperature rise across engine	°C	°F	7.9	14.2	7.9	14.2
Heat rejected to coolant at rated power	kW	Btu/min	78.4	4,461	73.5	4,182
Total heat radiated to room at rated power	kW	Btu/min	13.6	774	12.7	723
Radiator fan load	kW	hp	8.0	10.7	8.0	10.7
Air Requirements						
Combustion air flow	m^3/min	cfm	12.9	456	12.6	445
Maximum air cleaner restriction	kPa	in H_2O	5	20	5	20
Radiator cooling air (zero restriction)	m^3/min	cfm	327	11,548	327	11,548
Generator cooling air	m^3/min	cfm	26.4	923	26.4	923
Allowable air flow restriction (after radiator)	kPa	in H_2O	0.12	0.50	0.12	0.50
Cooling airflow (@ rated speed)						
Rate with restriction	m^3/min	cfm	317	11,195	317	11,195
Exhaust System						
Maximum allowable backpressure	kPa	in Hg	15	4.4	15	4.4
Exhaust flow at rated kW	m^3/min	cfm	31.5	1,112	30.5	1,077
Exhaust temperature at rated kW –						
Dry exhaust	°C	°F	625	1,157	610	1,130
Generator Set Noise Rating* (without attenuation) at 1 m (3 ft)	dB(A)		97.3		97.3	

Generator Technical Data		277/480V	266/460V	127/220V	120/240V 120/208V	347/600V
Motor Starting Capability:	(kVA)					
(30% voltage dip)	Self excited	420	391	363	330	N/A
	PM excited**	548	511	476	433	511
	AREP excited	548	511	476	433	511
Full Load Efficiencies:	Standby	92.9	92.9	92.9	92.5	92.9
	Prime	93.1	93.1	93.1	92.8	93.1
Reactances (per unit):	X_d	2.90	3.16	3.45	3.86	3.16
Reactances shown are applicable to the standby rating.	X'_d	0.10	0.11	0.12	0.13	0.11
	X''_d	0.058	0.063	0.069	0.078	0.063
	X_q	1.74	1.89	2.07	2.32	1.89
	X''_q	0.069	0.075	0.082	0.092	0.075
	X_2	0.063	0.069	0.075	0.084	0.069
	X_0	0.005	0.005	0.006	0.007	0.005
Time Constants:		t'_d 100 ms	t''_d 10 ms	t'_{do} 2966 ms	t_a 15 ms	

* dB(A) levels are for guidance only
** With PMG Excited Option AVR12

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LEHE5521-01 (04-07)

www.cat-electricpower.com

PV Specifications

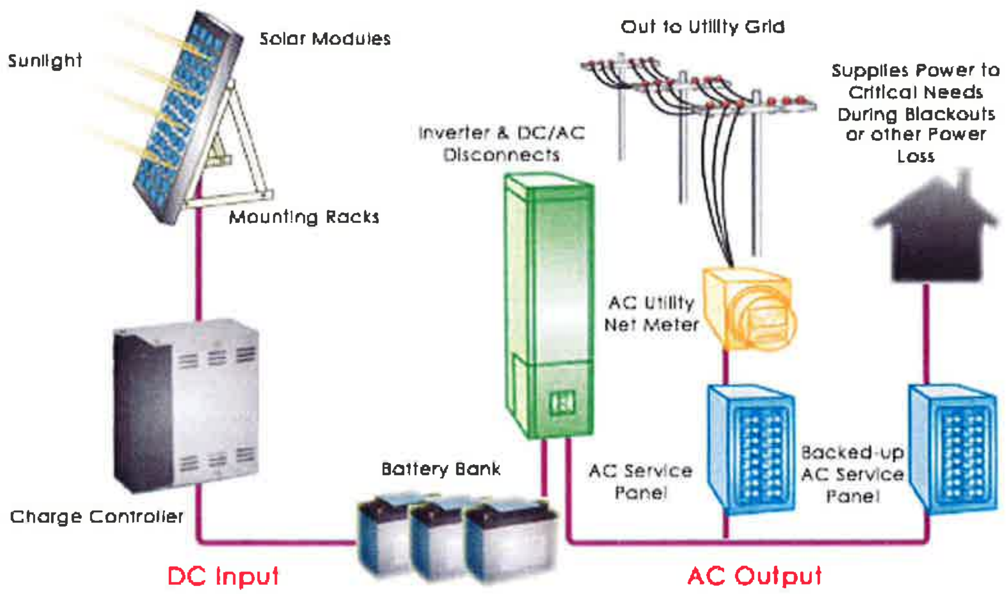
B2.3

VES 2550W Gridtie with Battery Backup $20,417.34

http://store.ves1.com/Grid-tied_with_Battery_Backup/cat91713_135233.aspx

The VES series of battery backup PV systems are designed to provide reliable AC electric power on a 24/7 basis, even if the utility is down. When the utility is in operation, the output of the PV system is first used to meet the needs of the customer, and then any excess electricity produced is sold back to the utility so someone else can use it. If, for any reason, the utility is shut down, the PV system will still provide power to selected customer loads, but will disconnect from the utility until the PV system determines that the utility power is stable. Then the PV system automatically reconnects to the utility. If the utility is down for a prolonged period, the system batteries will provide electricity to the customer emergency loads when the sun is not shining.

These Systems can be used anywhere in the U.S. However they are specifically designed for the Florida Environment. This includes meeting hurricane wind zone specifications.



Item Qty Description
1 15 Evergreen Solar ES-170-RL Modules (170W each)
2 1 Package UV resistant wire ties
3 15 Lay-In Ground Lugs with SS set screws and mounting hardware
4 1 Module Mounting Rail Set (See details for region)
5 2 Tube 50-year Weather Sealant
6 2 6x6x4-inch PVC W/P Junction Box
7 1 5-pole & 7-pole UL-listed terminal strips for JBs
8 7 Cord connectors (1/2" KO, 5 2-hole & 2 1-hole)
9 1 Outback PSPV Combiner Box with 1 negative bus
10 5 1P 15A dc breakers for PSPV
11 1 DC Surge Arrestor
12 1 Outback PS2DC DC Component Enclosure
13 1 60A DC Circuit Breaker (Array Disconnect)
14 1 60A DC Circuit Breaker (Charge Controller Disconnect)
15 1 GFDI assembly
16 1 175A DC Circuit Breaker
17 1 Set of pos, neg and ground bus
18 1 Outback MX-60 Charge Controller
19 1 Outback GVFX-3648 Inverter
20 1 Outback PS2AC AC Component Enclosure
21 1 1P60A AC Breaker
22 1 Set of AC in, AC out, neutral & gnd bus
23 1 Inverter Bypass Switch
24 4 1P15A AC Breakers
25 1 60A visible, lockable, load break W/P Disconnect
26 8 Concorde PVX-1080T Sealed LA Batteries or options
27 1 Set 2/0 battery cables (2 6-ft & 8 13-inch)
28 1 Mate Display Unit
29 1 ea Hub 4, AC & DC inverter covers, PS2MP mounting plate

All other parts for the system, such as THWN-2 wire, PVC conduit, conduit fittings,
straps and mounting screws are standard AC electrical components that are readily available
from your favorite electric parts supplier.

Manufacturers' Documents Included in this System Manual

Evergreen Solar ES-170RLPV Module Data Sheets
Unirac Solar Mount Installation Instructions and Code Compliant Planning and Assembly
Outback PSPV Combiner Box and PS2DC DC Component Enclosure Data Sheets
Outback MX-60 MPPT Charge Controller Instruction and Installation Manual
Outback FX-3648 Inverter Instruction and Installation Manual
Outback PS2AC AC Component Enclosure Data Sheets
Concorde PVX-1080T Battery Data Sheets

Water Cisterns

B2.4

270 Gallon Water Tank

Part Number:	GRN270-31TT
Capacity:	270 Gallon Plastic Water Storage Tanks
Size:	31" dia. x 85"H
USD Price:	219.99
USD Shipping:	Call For Shipping Rate 866 310 2556

Contact Us .

Add To Cart

270 Gallon Above Ground Water Storage Tank

Made From: Food Grade Safe FDA Approved Polyethylene Plastic

ONLINE ORDERS SHIP GREEN

Your 270 Gallon Water Tank Comes With:

8" Vented Manway
1" Female NPT Threaded Inlet Fitting
1-1/2" Female NPT Threaded Outlet Fitting

Available Colors By Request
-Green
-Black
-White
-Blue

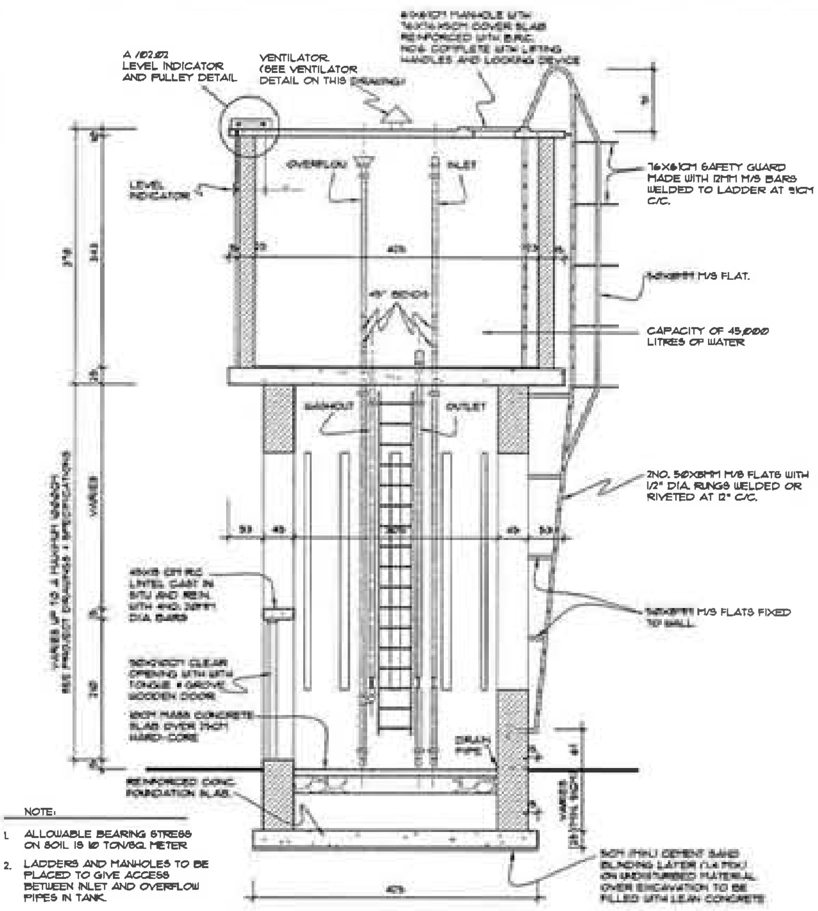
Perfect Tank For:

-Food Grade Safe Potable Water Storage
-Emergency Water Storage
-Rainwater Collection
-Air Conditioner Condensation
-Garden Rainwater Collection Barrels

Click "Add to Cart" to Order

Water Tower Specifications

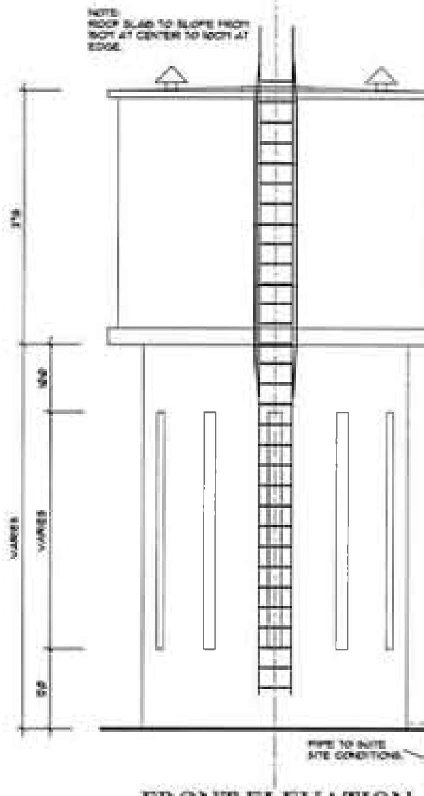
B3



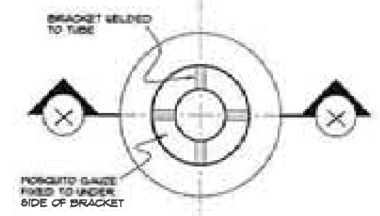
SECTION A/02.01
SCALE 1:50

NOTE:

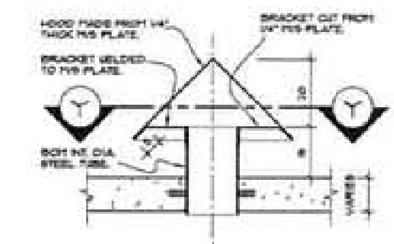
1. ALLOWABLE BEARING STRESS ON SOIL IS 10 TON/SQ. METER
2. LADDERS AND MANHOLES TO BE PLACED TO GIVE ACCESS BETWEEN INLET AND OVERFLOW PIPES IN TANK.
3. LADDERS AND ALL OTHER STEEL FIXTURES TO BE GALVANIZED.
4. BLOCK WORK AGGREGATES TO BE CHIPPINGS BETWEEN 1/4" TO 1/2" SIZE.



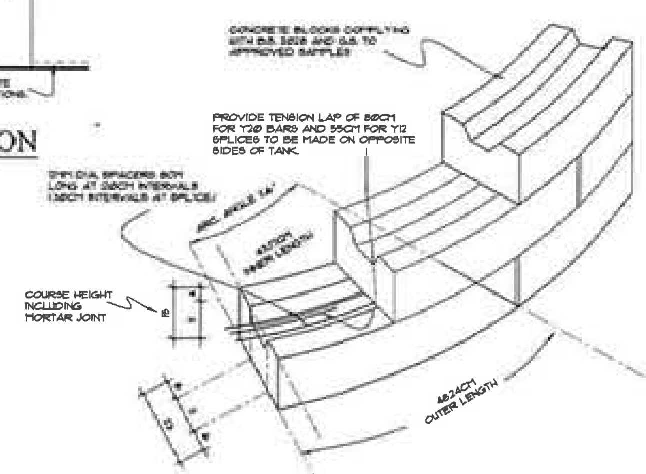
FRONT ELEVATION
SCALE 1:50



HORIZONTAL SECTION Y-Y



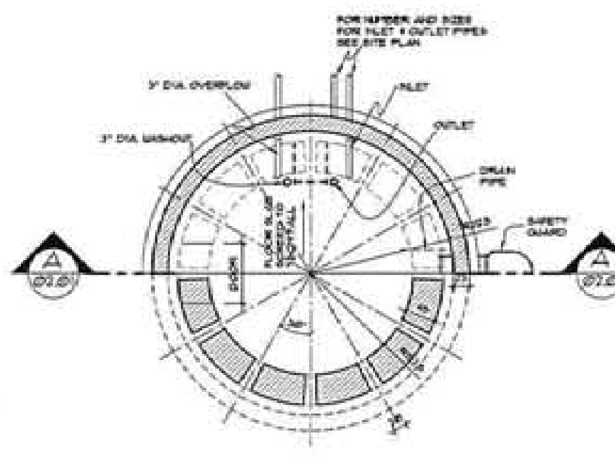
VERTICAL SECTION X-X VENTILATOR DETAIL
SCALE 1:10



DETAIL OF BLOCK WORK
NOT TO SCALE

GENERAL NOTES:

1. ALL WORK TO BE DONE IN ACCORDANCE WITH "GENERAL SPECIFICATIONS OF MSAADA - 2005 EDITION.
2. ALL STEEL MUST BE BENT COLD AND SHALL COMPLY WITH B.S. 4449 (HOT ROLLED HIGH YIELD STEEL GRADE 460/425).
3. CONCRETE MIX SHALL BE IN ACCORDANCE WITH G.S. AS FOLLOWS:
   FOUNDATION SLAB IN GROUND: MIX C (1:2:4)
   ALL OTHER REINFORCED CONCRETE: MIX D (1:1½: 3)
4. NO CONCRETE WORK SHALL BE DONE UNTIL THE PLACEMENT OF STEEL REINFORCEMENT HAS BEEN INSPECTED AND APPROVED BY THE ARCHITECT/ENGINEER.
5. AGGREGATE IS TO BE COURSE AND FINE. IT IS TO BE CLEAN AND DEVOID OF FOREIGN MATTER AND TO COMPLY WITH B.S. 882.
6. CONCRETE COVER TO REINFORCEMENT IS TO BE 75MM IN FOOTINGS AND 20MM IN SLABS
7. CONSTRUCTION BREAKERS AND SHUTTERING STRIPPING TIME TO BE DIRECTED AND APPROVED BY ARCHITECT / ENGINEER.
8. CURING: THE EXPOSED SURFACE OF THE CONCRETE SHALL BE KEPT MOIST FOR A MINIMUM OF 7 DAYS AFTER POURING.
9. INTERNAL WATERPROOFING OF WATER TANK IS TO BE PROVIDED BY A 19MM THICK WATER PROOF RENDERING HAVING A WATERPROOFING ADDITIVE APPROVED BY A/E.
10. ANY DISCREPANCY IN THIS SET OF DRAWINGS SHOULD IMMEDIATELY BE BROUGHT TO THE ATTENTION OF THE A/E
11. PROVIDED THE BEARING CAPACITY OF THE SOIL ALLOWS IT, THE HEIGHT OF THE RAISER FOR THE STORAGE TANK CAN BE INCREASED WITH UP TO THE DOUBLE OF ITS OWN HEIGHT, BUT THE A/E IS THEN FIRST TO APPROVE THE SOIL BEARING CAPACITY (UP TO 16 TONS/ SQ. METRE



PART TANK & WALL PLAN
SCALE 1:50

CIRCULAR WATER STORAGE TANK ON RAISER

Drawing: STANDARD 45,000 LITRE CIRCULAR WATER STORAGE TANK ON RAISER.

Scale: AS SHOWN

STD
17.02.01

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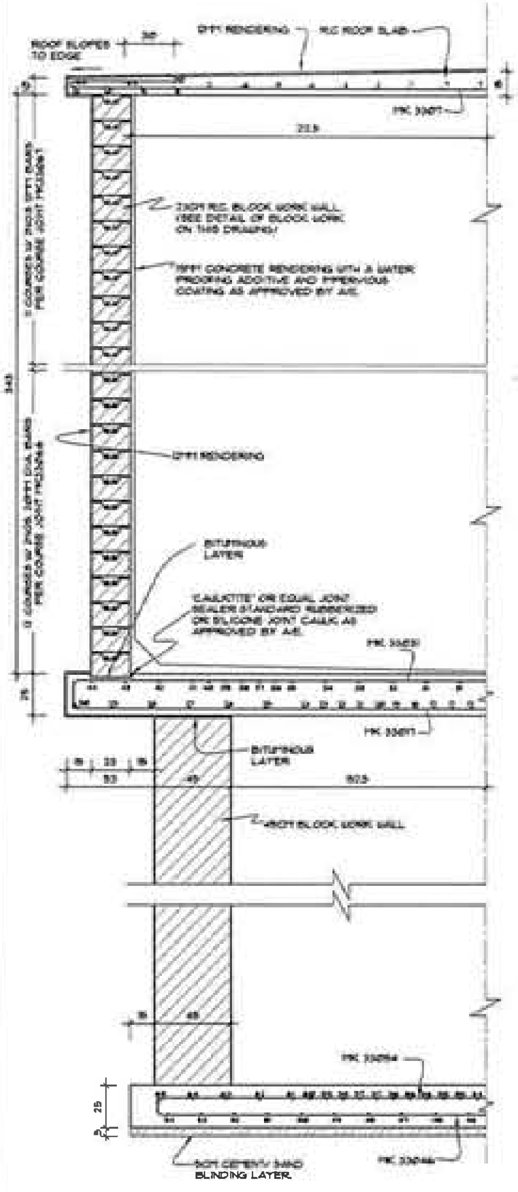
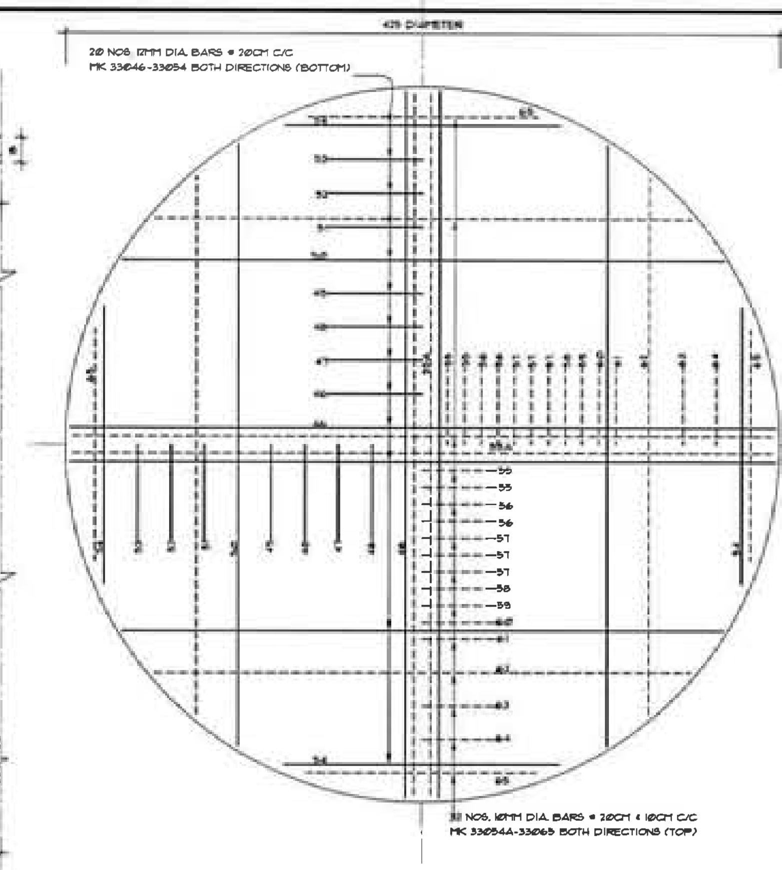


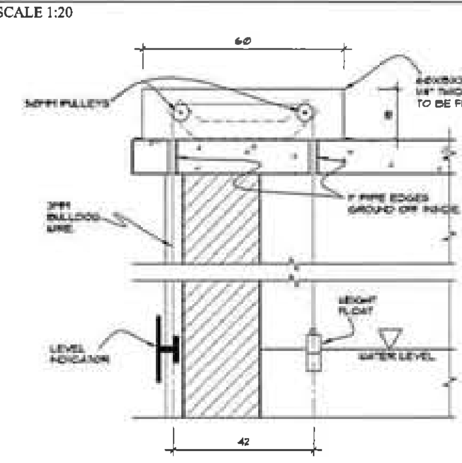
TYPICAL SECTIONAL DETAIL

SCALE 1:20



FOUNDATION REINFORCEMENT LAYOUT PLAN

SCALE 1:20



A /02.02 (LEVEL INDICATOR AND PULLEY DETAIL)

SCALE 1:10

BAR BENDING SCHEDULE

MARK NO.	LOCATION	CONFIGURATION	[illegible] (DEG)	[illegible] (DEG)	DIA. (MM)	LENGTH (CM)	READ NO.	TOTAL LENGTH
33001	IN ROOF BOTTOM	[illegible]	436	61	10	477	8	3762
33002	"	SAME AS MK. 33001	[illegible]	61	10	[illegible]	4	[illegible]
33003	"	"	[illegible]	61	10	[illegible]	4	[illegible]
33004	"	"	[illegible]	61	10	[illegible]	4	[illegible]
33005	"	"	[illegible]	61	10	[illegible]	4	[illegible]
33006	"	"	[illegible]	61	10	[illegible]	[illegible]	[illegible]
33007	"	"	[illegible]	61	10	[illegible]	[illegible]	[illegible]
33008	"	"	[illegible]	61	10	[illegible]	[illegible]	[illegible]
33009	"	"	[illegible]	61	10	[illegible]	4	[illegible]
33010	"	"	[illegible]	61	10	[illegible]	4	[illegible]
33011	"	"	[illegible]	61	10	[illegible]	[illegible]	[illegible]
33012	"	"	[illegible]	61	10	[illegible]	[illegible]	[illegible]
33013	"	"	[illegible]	61	10	[illegible]	[illegible]	[illegible]
33014	"	"	[illegible]	30	10	[illegible]	[illegible]	[illegible]
33015	"	STRAIGHT	[illegible]	-	10	[illegible]	[illegible]	[illegible]
33016	IN MANHOLE	STRAIGHT	[illegible]	-	10	[illegible]	[illegible]	[illegible]
33017	IN FLOOR BOTTOM	[illegible]	436	-	12	525	12	6300
33018	"	SAME AS MK. 33017	[illegible]	-	12	[illegible]	4	[illegible]
33019	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33020	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33021	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33022	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33023	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33024	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33025	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33026	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33027	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33028	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33029	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33030	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33031	IN FLOOR TOP	[illegible]	453	-	10	556	8	4448
33032	"	SAME AS MK. 33031	[illegible]	-	10	[illegible]	8	[illegible]
33033	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33034	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33035	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33036	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33037	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33038	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33039	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33040	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33041	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33042	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33043	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33044	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33045	"	[illegible]	[illegible]	-	10	[illegible]	44	[illegible]
33046	IN FOUNDN. BOTTOM	[illegible]	475	-	12	475	8	[illegible]
33047	"	SAME AS MK. 33046	[illegible]	-	12	[illegible]	4	[illegible]
33048	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33049	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33050	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33051	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33052	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33053	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33054	"	"	[illegible]	-	12	[illegible]	4	[illegible]
33055A	IN FOUNDN. TOP	[illegible]	475	-	10	440	8	[illegible]
33055	"	SAME AS MK. 33055A	[illegible]	-	10	[illegible]	[illegible]	[illegible]
33056	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33057	"	"	[illegible]	-	10	[illegible]	8	[illegible]
33058	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33059	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33060	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33061	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33062	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33063	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33064	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33065	"	"	[illegible]	-	10	[illegible]	4	[illegible]
33066	IN WALL	STRAIGHT	-	-	[illegible]	-	-	[illegible]
33067	IN WALL	STRAIGHT	-	-	12	-	-	[illegible]
33068	IN ROOF TOP	[illegible]	[illegible]	-	10	140	4	560
33069	"	SAME AS MK. 33068	[illegible]	-	10	[illegible]	4	[illegible]
33070	"	"	[illegible]	-	10	[illegible]	3	[illegible]
33071	"	"	[illegible]	-	10	[illegible]	2	[illegible]

NOTE:

1. ALL TOP BARS ARE SHOWN DOTTED.
2. FIGURES SHOWN ONTHE BARS ARE THE LAST TWO DIGITS OF MARK NO. SHOWN IN BENDING SCHEDULE
3. SPLICING BARS:
   THE REINFORCING BARS SHALL BE LAID IN CONTINUOUS LENGTHS WHERE EVER POSSIBLE. EXCEPTIONS SHALL BE MADE ONLY WITH APPROVAL OF ARCHITECT/ ENGINEER AND SHALL BE IN ACCORDANCE WITH THE FOLLOWING GUIDE LINES:

DIAMETER OF BAR	SPLICING LENGTH
10MM	35CM
12MM	60CM
14MM	63CM
20MM	85CM

CIRCULAR WATER STORAGE TANK ON RAISER

Date	[illegible]
Revisions	[illegible]
Scale	AS SHOWN
Drawn	JLM [illegible]
Approved	[illegible]

Drawing: STANDARD 45,000 LITRE CIRCULAR WATER STORAGE TANK ON RAISER.

STD

17.02.02

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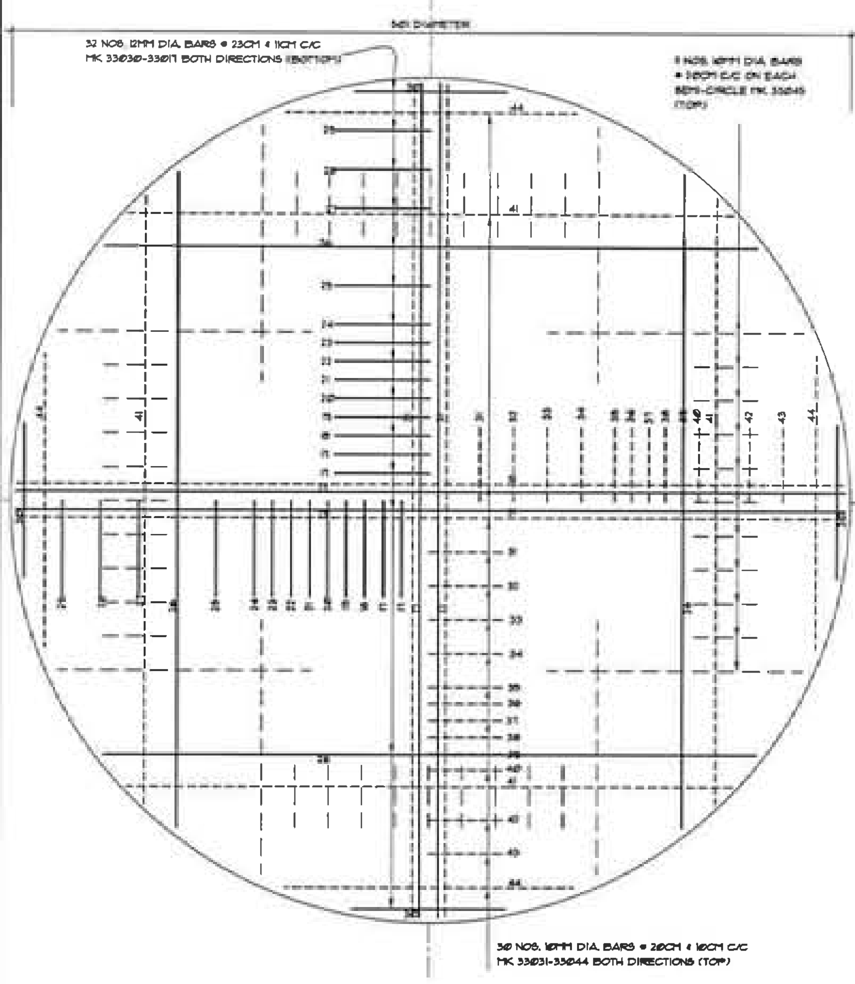
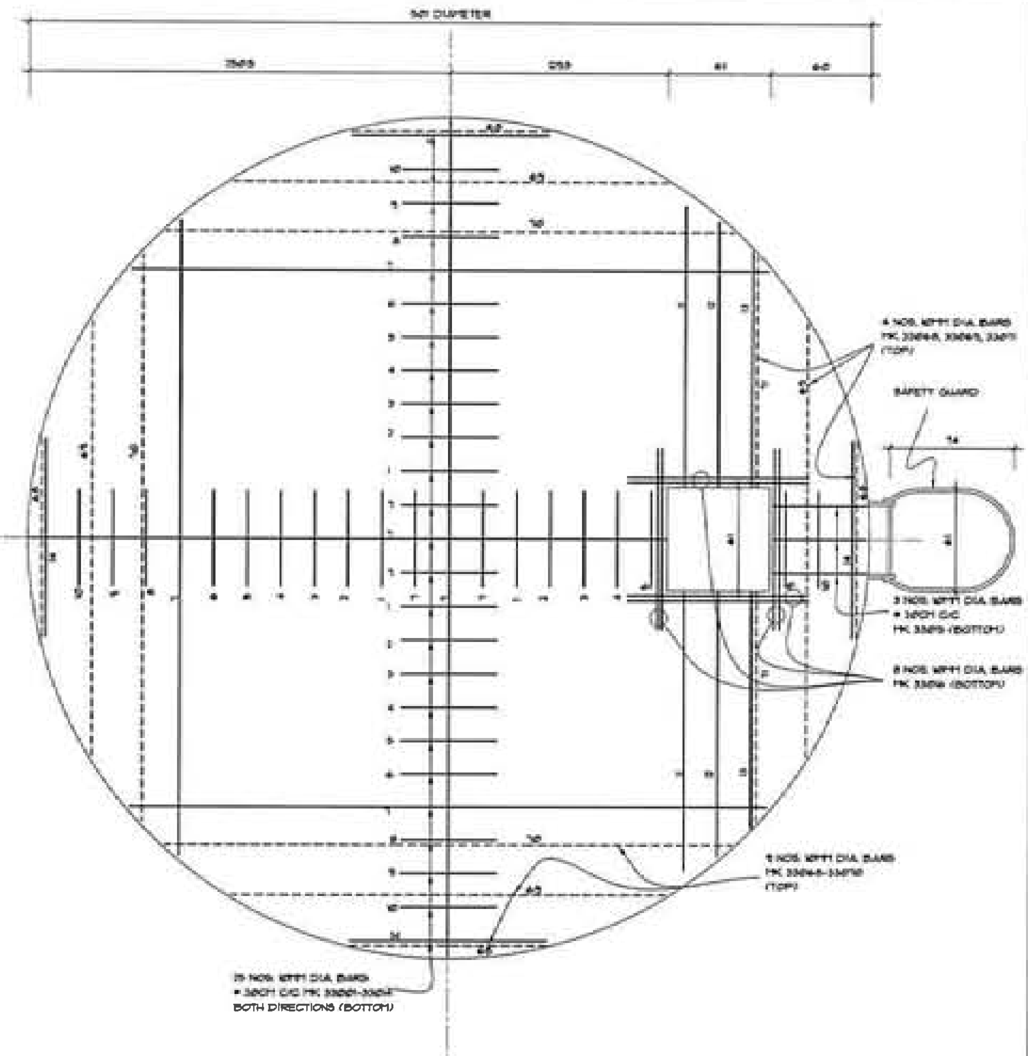


FLOOR SLAB REINFORCEMENT LAYOUT PLAN

SCALE 1:20



ROOF SLAB REINFORCEMENT LAYOUT PLAN

SCALE 1:20

CIRCULAR WATER STORAGE TANK ON RAISER

Drawing: STANDARD 45,000 LITRE CIRCULAR WATER STORAGE TANK ON RAISER.

STD 17.02.03

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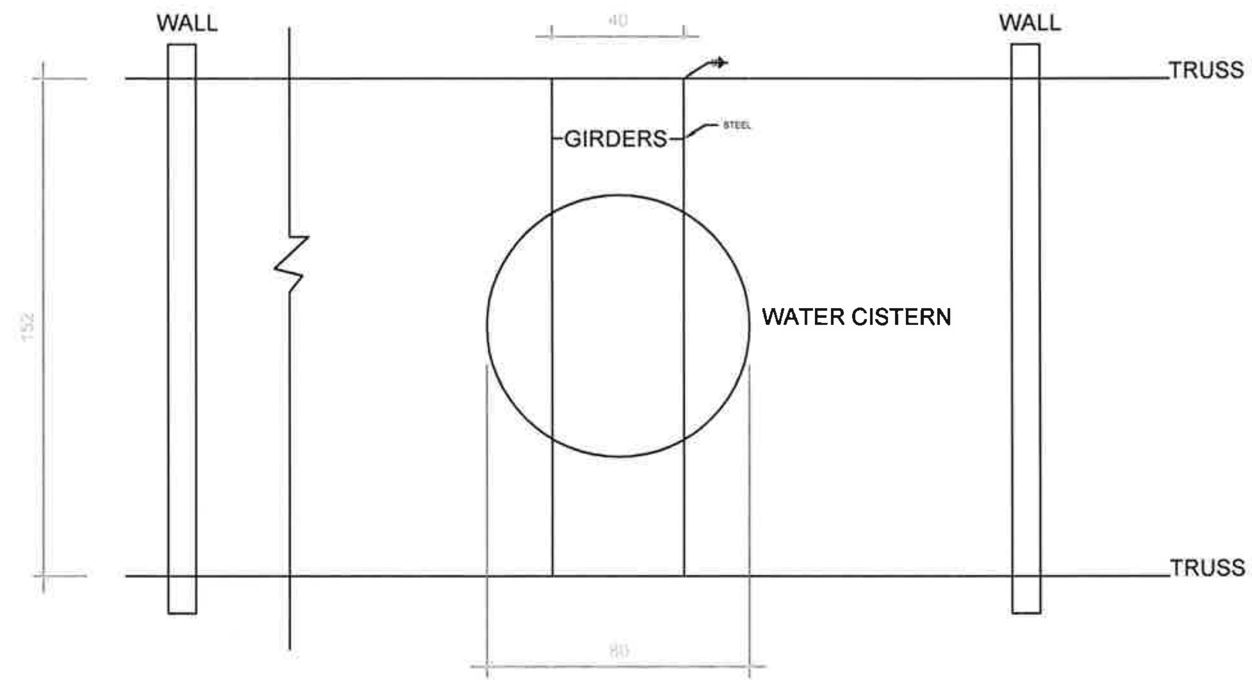
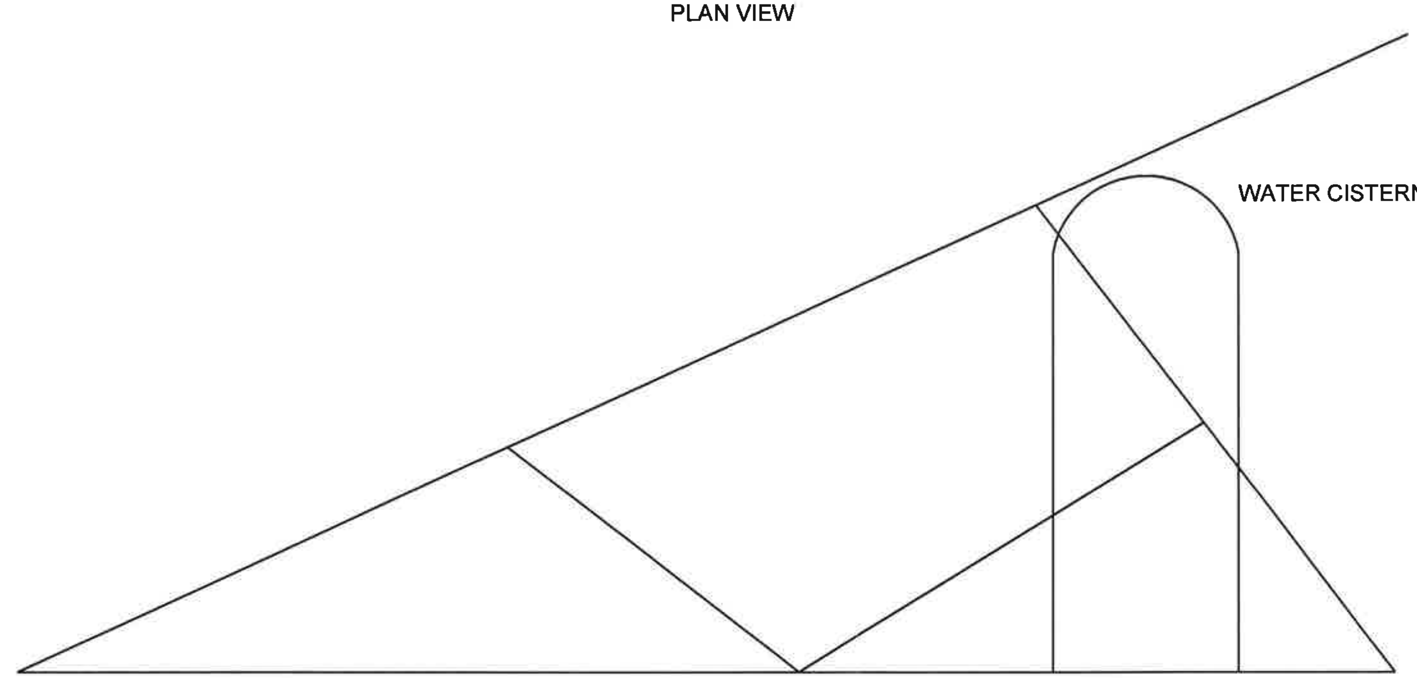
Cistern Location on Trusses

B4



PLAN VIEW



TRUSS SECTION

CISTERN ON TRUSS
US
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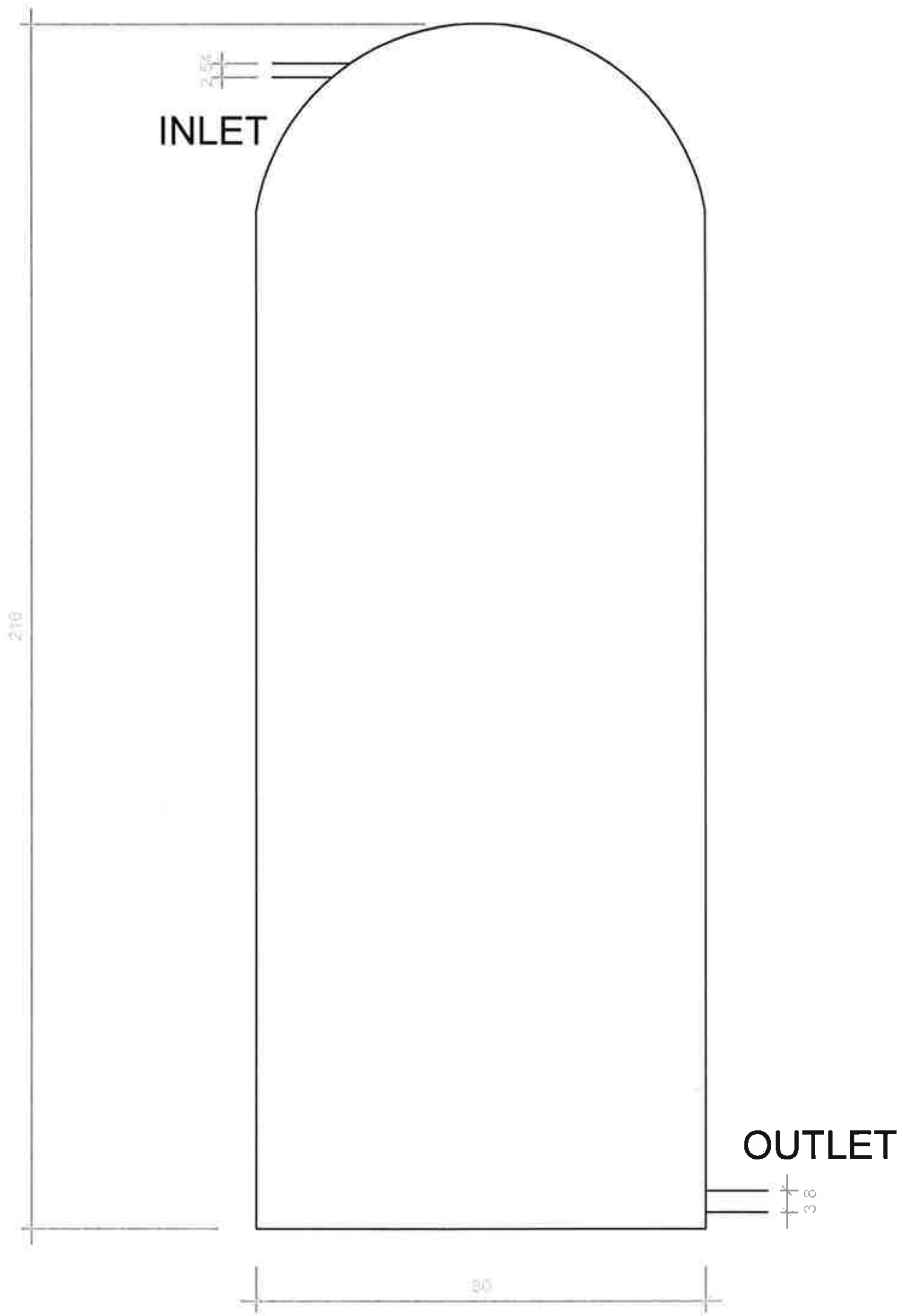
Cistern Connection Detail

B5



SECTION VIEW

US

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Septic Calculations

B6

Design Flow

In order to determine the necessary flow capacity of the on site sewer system for the university, the water demand must be calculated. This flow will be used to size both the septic system and the potable water demand of the well.

The flowing calculations are based on the Washington State Department of Health manual, *Design Standards for Large Onsite Sewer Systems*.

Design Flow Data

Table 1-B.
Design Flows for Facilities Other than Residential Development (Reference 8)

Discharge Facility	**Design Units**	**Flow** (gpd)**	**Duration (hr)**
Schools with showers and cafeteria	per person	16	8
Schools without showers and with cafeteria	per person	12.6	8
Schools without showers and without cafeteria	per pers	10	8

Calculations

Q [gpd/person]	Q [lpd/person]	Max Occupants	Q [lpd]	Q [lpd] (Reduced by 30%*)
10.00	37.80	1,049	39,652.20	11,895.66

*Country Reduction Factor was 30% to account for cultural water demand differences between the United States and Sudan.

This flow of 11,896 lpd was confirmed base on the World Health Organization's data for Eastern Africa (source: http://www.who.int/countries/caf/en/):

Country*	Q [m^3/year/person]	Q [lpd/person]	Max Occupants	Q [lpd]	Q [lpd] (21% Domestic Water Demand)
Central African Republic	27.00	73.97	1049	77,594.53	16,294.85

*There is no WHO water data for the country of Sudan. The Central African Republic boarders Sudan to the southwest, and is assumed for our purposes to have similar domestic water demands.

A flow of 11,896 lpd is reasonable within the common domestic water demand of Eastern Africa. This number will also be the wastewater flow.

Option One: Septic Tanks and Soakage Pits

Septic tank and soakage pit sizing is based on the MSSADA specification for Septic Tanks and Soakage Pits. The septic tanks and soakage pits are designed for a 24 hour use, while our total wastewater flow is only designated for 8 hours. The difference will be accounted for by reducing the wastewater flow by two thirds.

Septic Tanks

The specification for septic tanks is based on numbers of persons; therefore the max occupancy of the university was reduced by two thirds. (MSAASA std. drawing 17.01.01)

TYPES OF SEPTIC TANKS

TYPE	FOR NOS. OF PERSONS	LENGTH A	WIDTH B	CHAMBER PARTTION C	D
I	10	210	100	100	45
II	17	300	120	150	65
III	25	380	140	190	85
IV	35	460	160	230	105
V	45	530	180	260	125
VI	60	630	200	310	150
VII	75	730	220	360	175
VIII	100	840	240	420	200

For 350 persons, four type VIII septic tanks will be required.

Soakage Pits

Flow, Q [lpd]	2/3 Reduced Q [lpd]	Hydraulic loading rate, lpd/m^2	Required Area, m^2
11895.66	3965.22	7.96	498.14

TYPES OF SOAKAGE PITS

TYPE	LENGTH E	DIAMETER F
I	95	240
II	125	300
III	175	400
IV	200	450
V	225	500
VI	265	580
VII	295	640

Based on the MSSADA specification for soakage pits, seven type V soakage pits will be required.

Option 2: Septic Tanks and Drain Field

In order to minimize the ecological footprint the septic system makes and maximize the useable space of the university's property, a septic tank and drain field combination was considered. The drain field can serve a double purpose of treated wastewater disposal and agricultural space for the students.

The volume of water that needs to be stored in equal to three times the daily flow:

Daily Flow [lpd]	Storage Needed [lpd]
11895.66	35686.98

Next, the septic tank volumes are calculated from the MSAADA standard drawing 17.01.01.

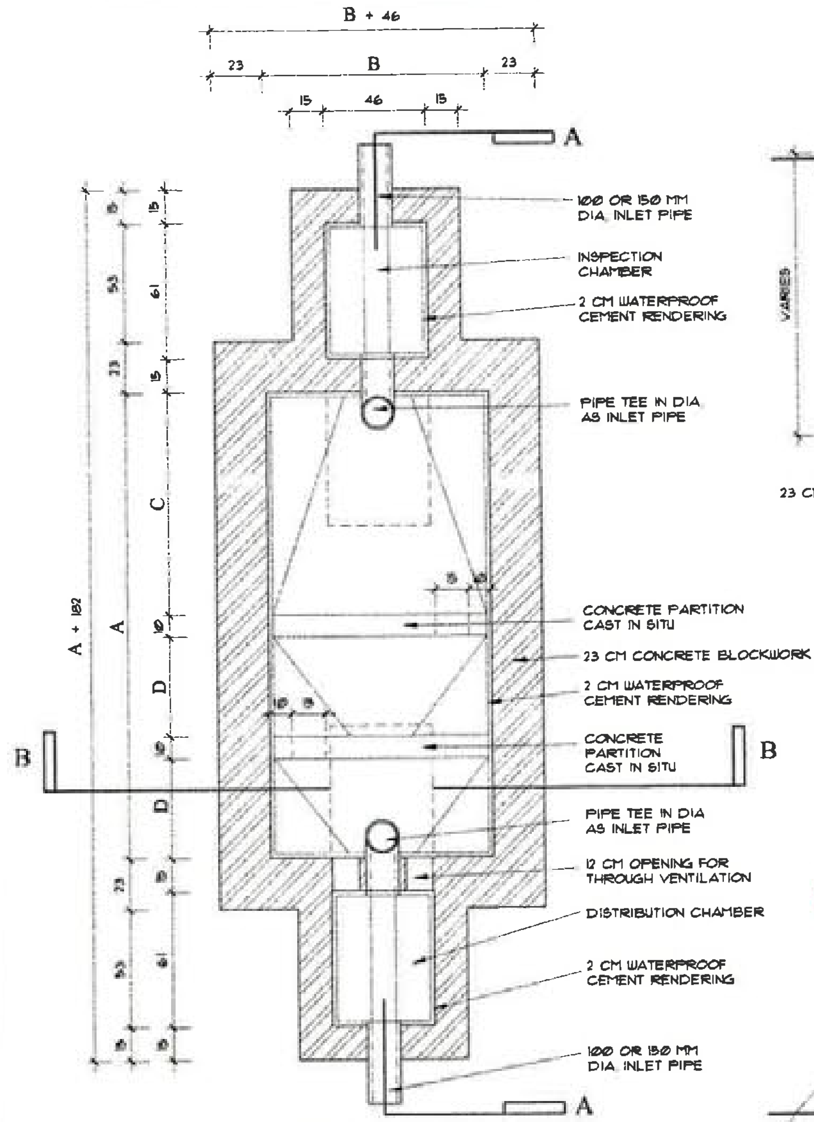
Type	length [cm]	width [cm]	depth [cm]	Volume [cm^3]	Liters
3	190	140	150	3990000	3990
4	230	160	150	5520000	5520
5	260	180	150	7020000	7020
6	310	200	150	9300000	9300
7	360	220	150	11880000	11880

From these calculations, three type seven tanks will be sufficient to handle the daily flow storage. Three tanks will be used when the entire university has been constructed (full build-out), before then two tanks will be sufficient. The third tank will be separated by a valve as indicated on the site plan drawings.

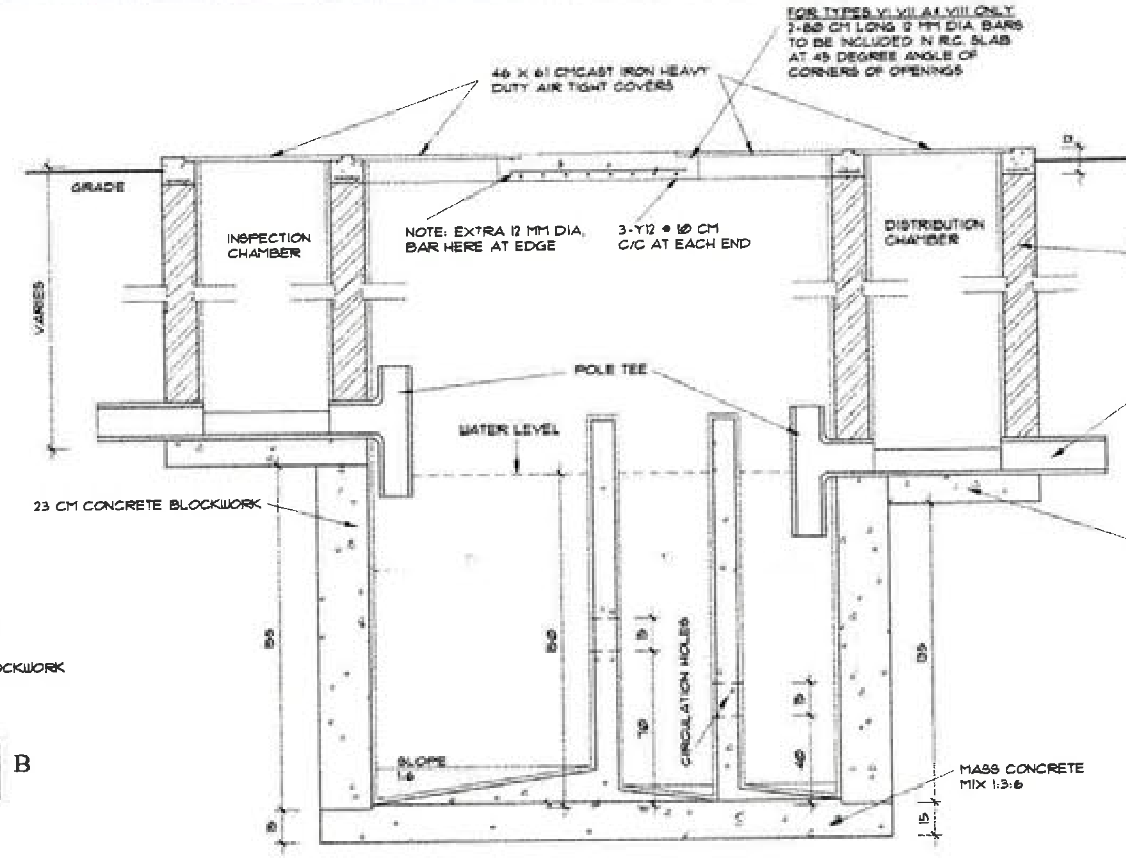
The drain field was sized based on the hydraulic loading rate of the soil, 7.96 lpd/m^2, and the requirements that the distribution pipes must be at least four meters apart, and each orifice must have at least one square meter of soil surrounding it. From these parameters we were able to calculate that the drainage area needs to be 4000 m^2. The site plan details the layout on the site.

Septic Tank Specifications

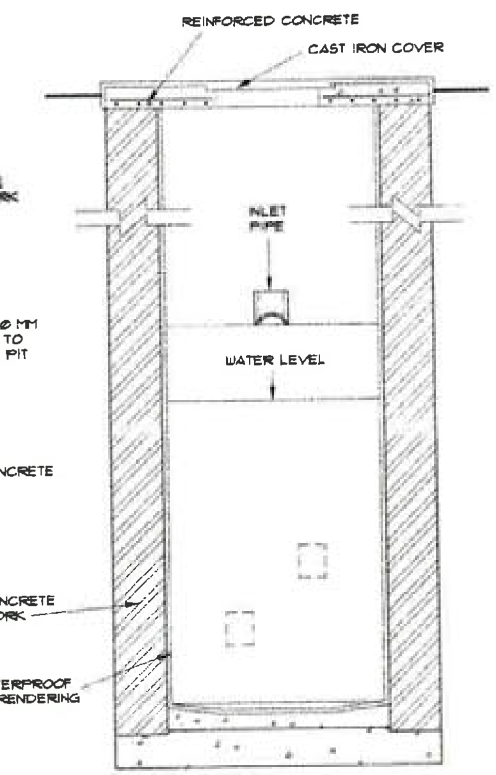
B7



PLAN OF SEPTIC TANK



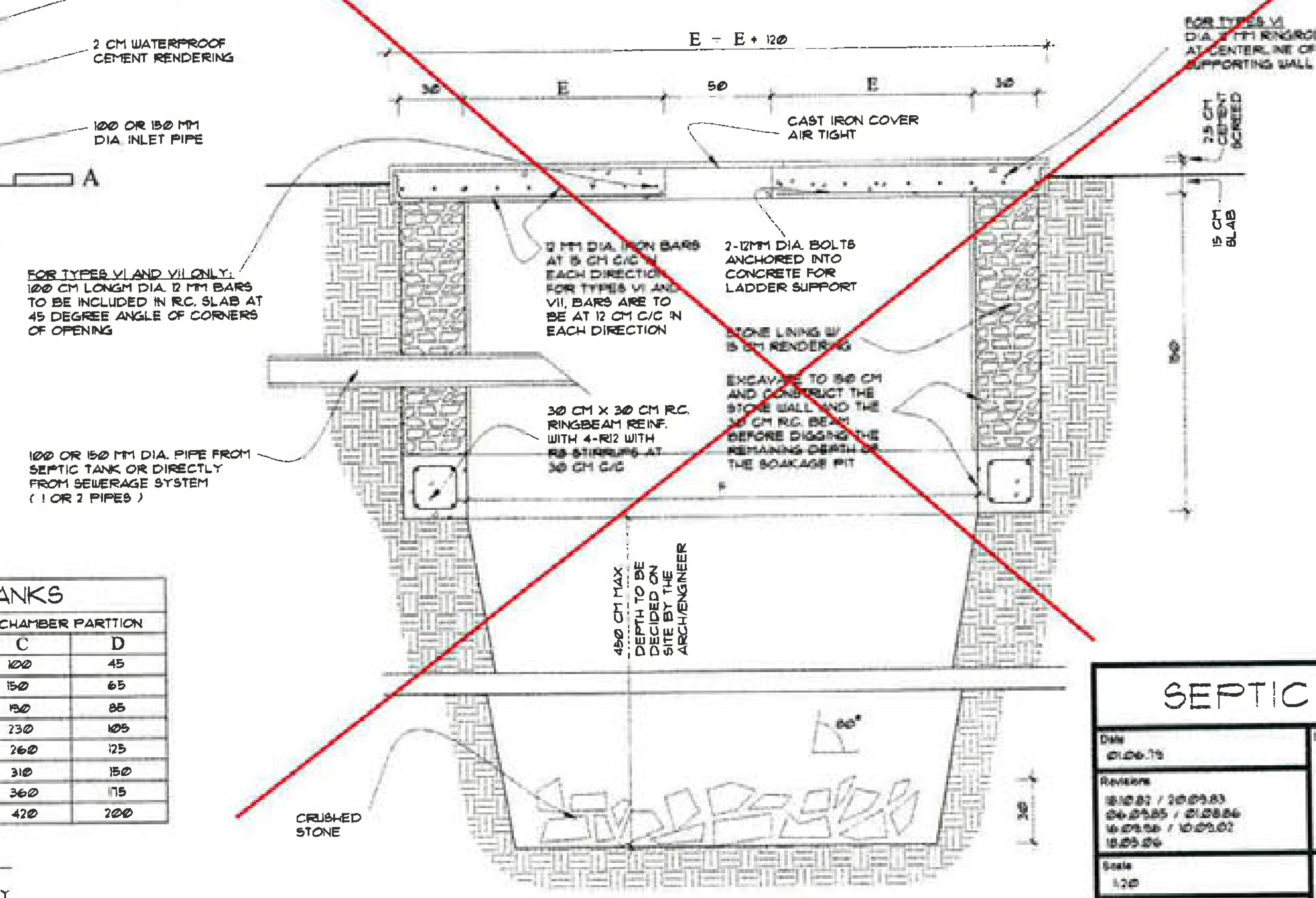
SECTION A-A



SECTION B-B

TYPES OF SOAKAGE PITS		
TYPE	LENGTH E	DIAMETER F
I	[illegible]	240
II	125	300
III	[illegible]	400
IV	200	[illegible]
V	225	500
VI	265	560
VII	295	640

SEE NOTE * 2 BELOW



SOAKAGE PIT SECTION

TYPES OF SEPTIC TANKS					
TYPE	FOR NOS. OF PERSONS	LENGTH A	WIDTH B	CHAMBER PARTTION C	CHAMBER PARTTION D
I	10	210	100	100	45
II	17	300	120	150	65
III	25	380	140	190	85
IV	35	460	160	230	105
V	45	530	180	260	125
VI	60	630	200	310	150
VII	75	730	220	360	175
VIII	100	840	240	420	200

NOTES:

1. FOR SOAKAGE PITS TYPE VI & VII IT'S RECOMMENDED THAT TWO SMALLER SOAKAGE PITS OF EQUAL CAPACITY BE USED WHERE SPACE ON SITE ALLOWS
2. FOR SEPTIC TANK TYPE VIII TWO SOAKAGE PITS TYPE V SHOULD BE USED

GENERAL NOTES:

1. ALL MEASUREMENTS AND DIMENSIONS ARE IN CENTIMETERS, IF NOTHING ELSE IS INDICATED.
2. ALL WORK TO BE DONE IN ACCORDANCE WITH 'GENERAL SPECIFICATIONS OF MSAADA - 2005 EDITION.
3. ALL REINFORCED CONCRETE IS TO BE IN MIX 1:2:4 AND ALL REINFORCEMENT STEEL TO BE HOT ROLLED MILD STEEL.
4. DIMENSIONS OF OUTLET PIPES FROM SEPTIC TANK PLUS INLET PIPE(S) TO SEPTIC TANK AND SOAKAGE PIT ARE TO BE IN ACCORDANCE WITH PROJECT DRAWINGS AND SPECIFICATIONS.

SEPTIC TANKS & SOAKAGE PITS

Date: 01.06.75

Revisions: 18.10.82 / 20.09.83, 04.09.85 / 01.08.86, 16.09.98 / 10.09.02, 18.05.06

Scale: 1:20

Drawn: PB, JM, NG, JA, TH

Approved: PB, AP

Drawing: STANDARD SEPTIC TANKS & SOAKAGE PITS WITH DETAILS

STD 17.01.01

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SPECIALIZING IN CHURCH - SPONSORED PROJECTS WORLDWIDE

Drainage Report

B8

Drainage Report

Weighted Average Rainfall [year = 6 month rainy season]

5.03 in/month * 6 months/year = 31.98 in/year

Levenworth

28-31 in/year

Isopluvials .

2 year, 24 hr	
	1.75
10 year, 24 hr	
	2.25

Rational Method

Q=CIA

Time of Concentration

Tc=Tt1+Tt2+Tt3

$Tt=L/(k*S^{.5})$

L	90
k (nearly bare ground)	420
S	0.03
Tt	1.24

Tc	**5**	
C (lawn, sandy soil)	**0.5**	
A (acres)	**5**	**10**
Q10 (cfs)	5.57	11.14
Q2 (cfs)	3.24	6.48
Q25 (cfs)	7.63	15.26

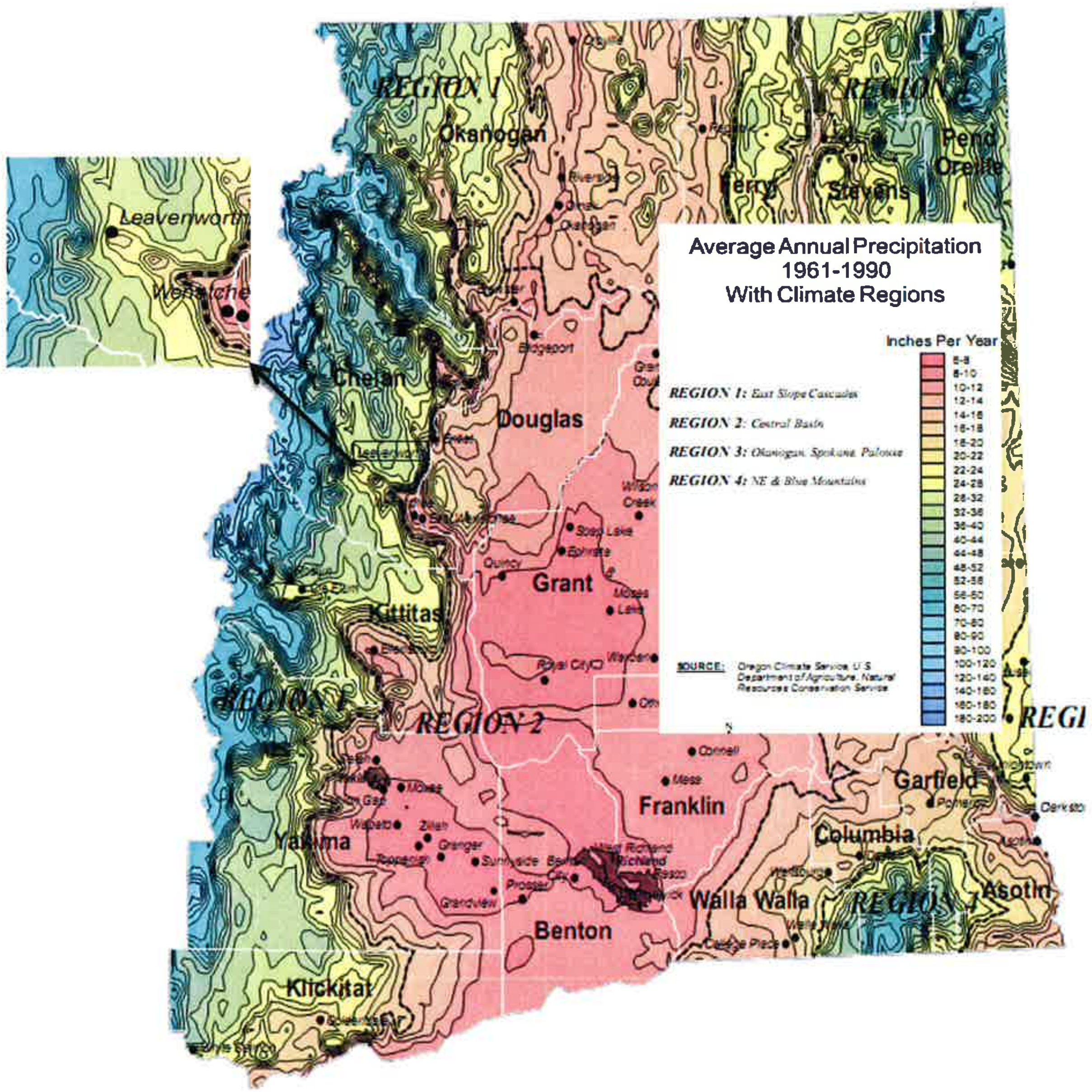
Rainfall Intensity

$I=m/(Tc)^n$

	10-year	2-year	25-year
m	5.62	3.04	7.94
n	0.575	0.53	0.594
I	**2.23**	**1.30**	**3.05**

Drainage Data Table

Site	Area [acres]	Q2 [cfs]	Q10 [cfs]	Q25 [cfs]
1	5	3.24	5.57	7.63
2	10	6.48	11.14	15.26


Average Annual Precipitation
1961-1990
With Climate Regions
Inches Per Year
6-8
8-10
10-12
12-14
14-16
16-18
18-20
20-22
22-24
24-28
28-32
32-36
36-40
40-44
44-48
48-52
52-56
56-60
60-70
70-80
80-90
90-100
100-120
120-140
140-160
160-180
180-200
REGION 1: East Slope Cascades
REGION 2: Central Basin
REGION 3: Okanogan, Spokane, Palouse
REGION 4: NE & Blue Mountains
SOURCE: Oregon Climate Service, U.S. Department of Agriculture, Natural Resources Conservation Service
REGION 1
REGION 1
REGION 2
REGION 4
REGION 4
Leavenworth
Wenatchee
Okanogan
Ferry
Stevens
Pend Oreille
Chelan
Douglas
Grant
Kittitas
Yakima
Franklin
Garfield
Columbia
Walla Walla
Asotin
Benton
Klickitat
Bridgeport
Quincy
Soap Lake
Ephrata
Moses Lake
Royal City
Warden
Connell
Mesa
Moxee
Zillah
Granger
Wapato
Toppenish
Sunnyside
Prosser
Grandview
Richland
West Richland
Pasco
Kennewick
Pomeroy
College Place

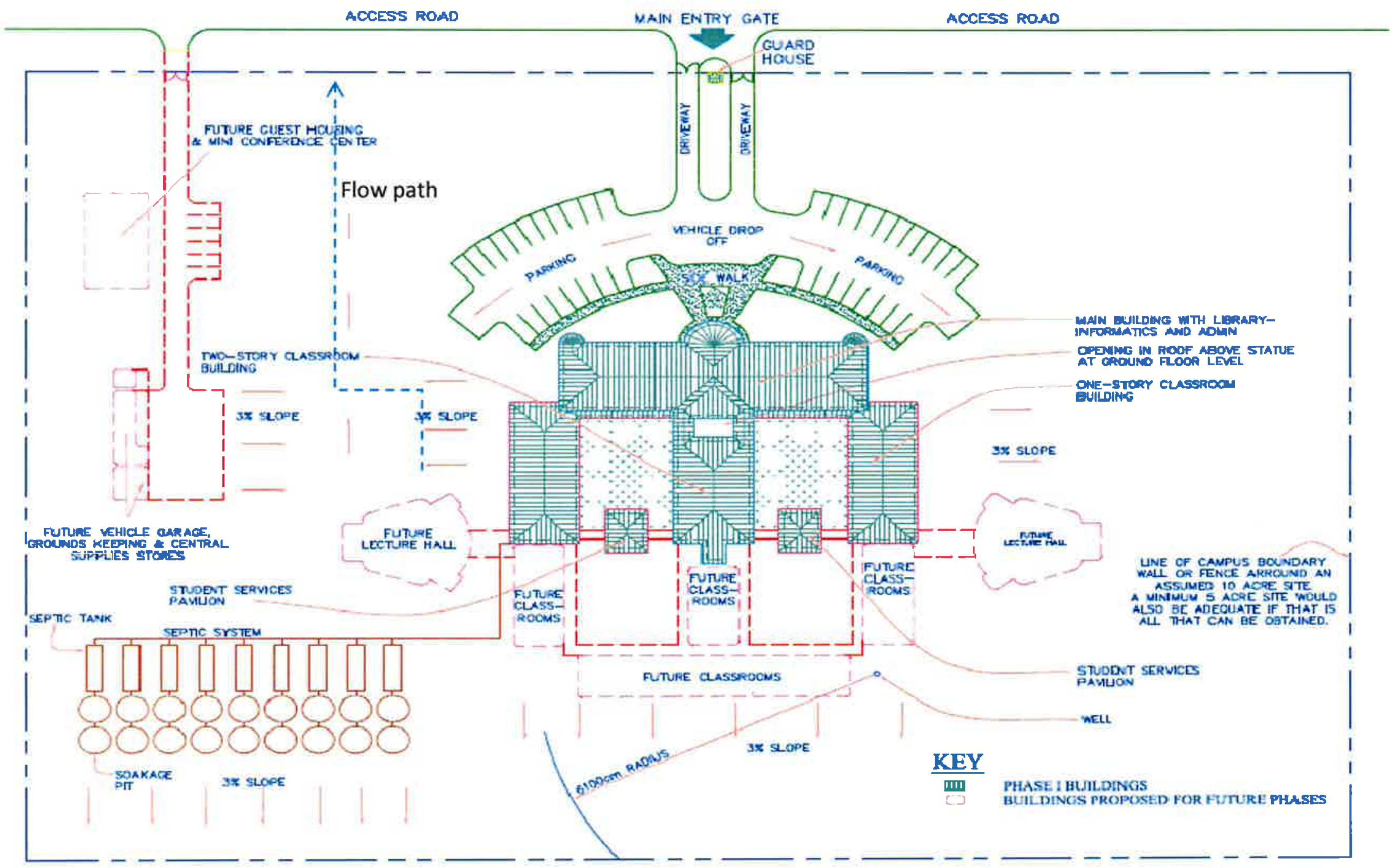
Rainfall Data for Juba, Sudan

	WorldClimate.com [mm]	Climate-Charts.com [mm]	NOAA (Wau, Sudan) [mm]
January	3.50	3.60	1.27
February	11.90	11.60	5.08
March	42.10	44.90	22.86
April	104.70	91.90	66.04
May	155.00	148.50	134.62
June	114.40	119.70	165.10
July	128.30	136.20	190.50
August	137.90	144.40	208.28
September	113.70	116.60	167.64
October	107.50	101.70	124.46
November	41.80	46.30	15.24
December	9.70	7.00	1.27
Average	80.88	81.03	91.86
Average Rainy Season	126.13	127.85	165.10

Rainy Season (April–October)

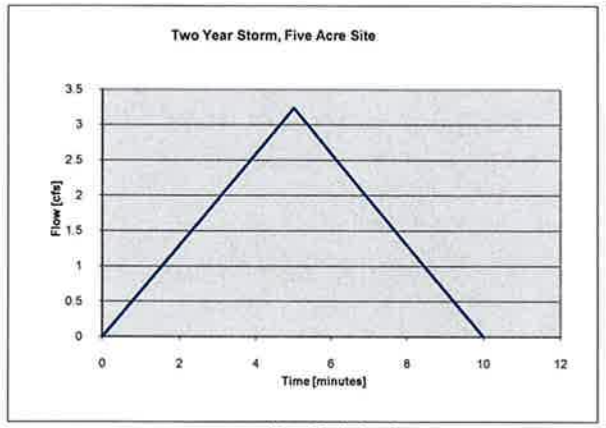
	WorldClimate.com [inches]	Climate-Charts.com [inches]	NOAA (Wau, Sudan) [inches]
January	0.14	0.14	0.05
February	0.47	0.46	0.20
March	1.66	1.77	0.90
April	4.12	3.62	2.60
May	6.10	5.85	5.30
June	4.50	4.71	6.50
July	5.05	5.36	7.50
August	5.43	5.69	8.20
September	4.48	4.59	6.60
October	4.23	4.00	4.90
November	1.65	1.82	0.60
December	0.38	0.28	0.05
Average	3.18	3.19	3.62
Average Rainy Season	4.97	5.03	6.50

Rainy Season (April–October)



	Drainage Data Table			
Site	Area [acres]	Q2 [cfs]	Q10 [cfs]	Q25 [cfs]
1	5	3.24	5.57	7.63
2	10	6.48	11.14	15.26

Hydrographs



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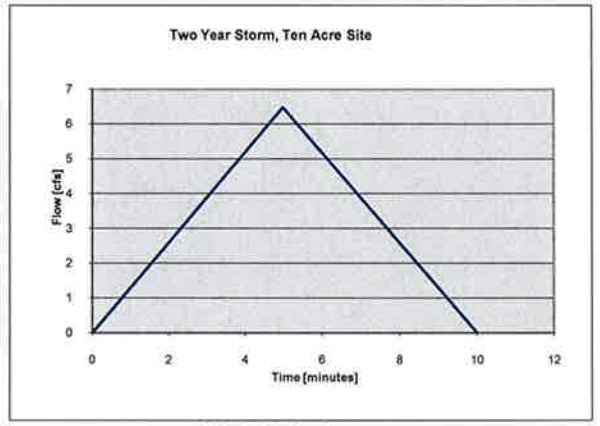

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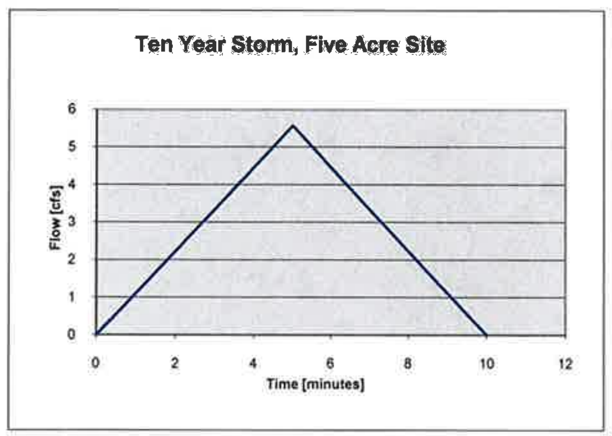

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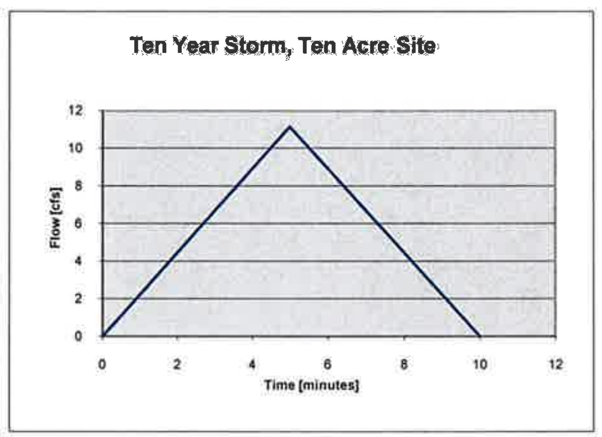

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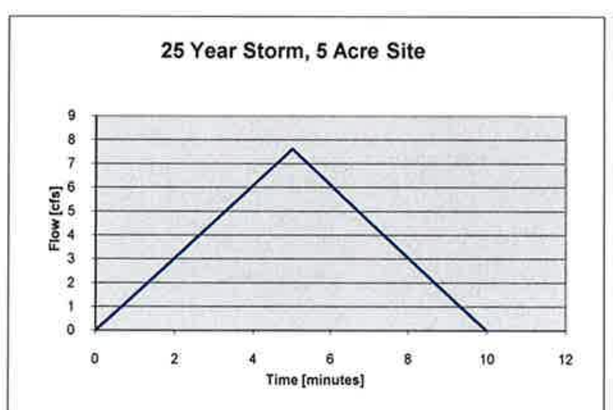

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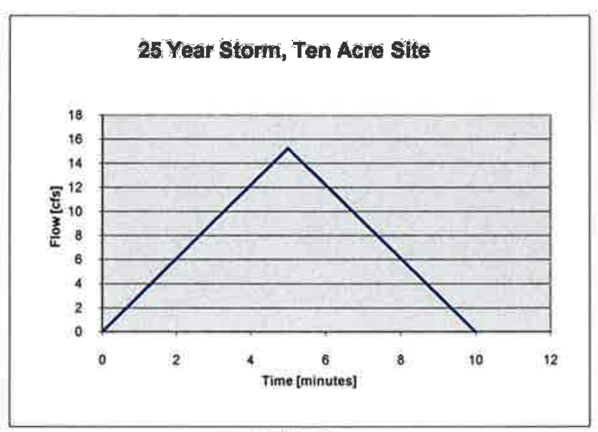


V=4578 cf

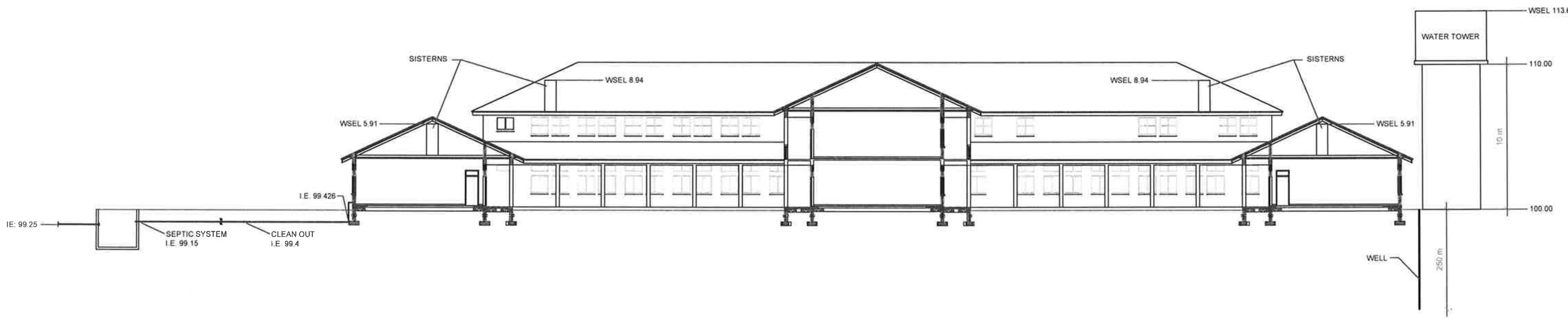
Materials Cost Estimate

B9

	Material	Quantity	[unit]	Cost [$] per	unit [unit]	Total Cost [$]
	6" PVC pipe	200	ft	1.5	1 ft	$300.00
Sewer, Septic, Drainfield	***6" perferated PVC pipe***	4921	ft	1.5	1 ft	$7,381.50
	Concrete	283.5	ft^2	3.3	1 ft^2	$935.55
	Concrete Blocks	1200	blocks	1.2	1 block	$1,440.00
	#4 rebar	100	lb	0.5	1 lb	$50.00
	Iron Cover	12		40	1	$480.00
Mechanical	***Generator***	1		18,000	1	$18,000.00
Water Supply	***3" PVC pipe***	200	ft	0.5	1 ft	$100.00
	Concrete Blocks	700	blocks	1.2	1 block	$840.00
	Concrete	154	ft^2	3.3	1 ft^2	$508.20
	Ladder	1		200	1	$200.00
	#4 rebar	200	lb	0.5	1 lb	$100.00
	#7 rebar	200	lb	0.5	1 lb	$100.00
	#3 rebar	200	ft	0.5	1 lb	$100.00
	Pump	1		784	1	$784.00
	Storage tanks	5	tanks	179	1 tank	$895.00
PV System	***Solar Module, Battery Bank, Hardwear, etc.***	1		20,417.00	1	$20,417.00
					Total	$52,631.25

Hydraulic Profile

B10



HYDRAULIC PROFILE

US

MSAADA Architects